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Loris S. Russell

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LORIS S. RUSSELL is Curator Emeritus in the Department of Vertebrate Palaeontology, Royal Ontario Museum, Toronto, Ontario.

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Fauna and Correlation of the Ravenscrag Formation (Paleocene) of Southwestern Saskatchewan

Abstract
The Ravenscrag Formation of southwestern Saskatchewan consists of 500 ft (150 m) or less of clays, shales, siltstones, and fine-grained sandstones, resting conformably on the uppermost Cretaceous Frenchman Formation, the base being a persistent coal seam. The formation is divisible into a lower portion of grey and brown clays and clayey sandstones, and an upper portion predominantly of buff siltstone and sandstone. Near the top of the formation there is a thick bed of kaolinized clay, the Willowbunch Member. Shells of freshwater molluscs occur abundantly in places and are closely related to those of the Fort Union formations of Montana and the Paskapoo Formation of Alberta. Most vertebrate remains are not diagnostic, but a fragmentary lower jaw from about 120 ft (36 m) above the formational base represents a new species of the Puercan (Lower Paleocene) mammalian genus *Carcinodon.* The transition from grey to buff portions of the formation rises stratigraphically from west to east, and from Saskatchewan to Montana. Fort Union equivalents of the Ravenscrag Formation are the Tullock and Lebo formations and possibly a small lower portion of the Tongue River. Age of the Ravenscrag is Paleocene, ranging from Puercan to Tiffanian.

Introduction

Correlation of the Upper Cretaceous and Tertiary formations of southern Alberta and Saskatchewan with those of Montana and North Dakota has been the broad theme of my field work from 1967 to 1972. Component parts of this project that have been completed or are in process of completion are the correlation of the Upper Cretaceous formations of southern Alberta (Russell, 1970), and of the Oligocene and Miocene formations of Saskatchewan. The present contribution deals with the Paleocene of southwestern Saskatchewan, from the Cypress Hills to Big Muddy Lake. The principal effort has been to find diagnostic vertebrate faunas, but the evidence of invertebrate fossils, stratigraphy, and lithology has been considered.

Previous Work

The first detailed examination of the Paleocene rocks of southern Saskatchewan was by G. M. Dawson (1874, 1875), in his capacity as geologist for the British North American Boundary Commission. Dawson's reports include sections of the "Lignite Tertiary" in Souris River valley, Big Muddy Valley ("Great Valley"), and along tributaries of Poplar River ("Pyramid Creek, Porcupine Creek") and Morgan Creek ("Bad Lands south of Wood Mountain"). At the last-named locality he designated what we now call Ravenscrag as Divisions α and β, the latter including in its lower part the dinosaur-bearing beds now called the Frenchman Formation. In addition to collecting bones from below the coal seam of Division β, Dawson observed impressions of leaves and shells of freshwater molluscs at several places in the lignite-bearing parts of the sequence (Ravenscrag Formation). In his general discussion of the "Lignite Tertiary" Dawson firmly correlated it with the "Fort Union Tertiary" of the Missouri Valley and, after reviewing the many variant opinions then current on the age of those rocks, concluded that they lie above the Cretaceous-Tertiary boundary, which should be placed at the top of his "Cretaceous No. 5—Fox Hill Group" in Saskatchewan, now called the Eastend Formation. The only difference between Dawson's view and that adopted today is that the lowest part of his "Lignite Tertiary" (i.e., the Frenchman Formation with its dinosaurian fauna) is now included in the Cretaceous System.

Dawson's subsequent work on the Canadian plains was in southern Alberta. In 1883 his former assistant, R. G. McConnell, made a reconnaissance of the Cypress Hills and Wood Mountain areas. In his report (McConnell, 1885) he applied the name Laramie to Dawson's Lignite Tertiary, but his description of it is mostly a direct quotation from Dawson (1875).

With the advent of settlement the coal and clay resources of southern Saskatchewan became more important, and the Geological Survey of Canada sent Bruce Rose to survey the geology of the Wood Mountain–Willow Bunch area in 1913 and 1914. In his report (Rose, 1916) he drew heavily on Dawson (1875) but introduced American nomenclature for the Cretaceous and Tertiary formations. His main contribution was recognition of the distinction between the "Lance formation" and the "Fort Union formation" (i.e., Frenchman and Ravenscrag), but he was uncertain as to the boundaries of the former and included in it what are now called the Whitemud and Battle formations. Rose failed to find fossil bones in the "Rock Creek badlands", which is difficult to understand. Following the usage of the U.S. Geological Survey at the time, he classified the Lance Formation as Eocene (?) and the Fort Union as Eocene.

N. B. Davis (1918) was the first to introduce local Canadian names for the Upper Cretaceous and Tertiary formations of southern Saskatchewan. His sequence, rearranged in the conventional order, is as follows:

Cypress Hills
Ravenscrag
Whitemud
Estevan
Fox Hills
Pierre

He drew the Cretaceous–Tertiary boundary at the top of the Fox Hills and grouped the Estevan, Whitemud, and Ravenscrag as subdivisions of the

Fort Union "formation". This worthy effort by Davis was unfortunately marred by his failure to recognize that there were two "Whitemud" deposits of kaolinized clay and sand, one immediately over the "Fox Hills" (the true Whitemud Formation) and another about 400 ft (120 m) higher in the sequence, in upper beds of the Ravenscrag Formation (Willowbunch Member). Hence the Estevan Formation of Davis was actually a lower part of the Ravenscrag Formation. This mistake is understandable, because the two kaolinized units are remarkably similar, and because there are few localities where both may be seen in their true vertical relationships.

The real stratigraphic succession was finally established by F. H. McLearn, who began in 1927 a series of detailed studies across the southern part of Saskatchewan in preparation for a regional map and memoir. In the first of his reports (McLearn, 1928) he recognized that the lower part of the Ravenscrag Formation, below the No. 1 coal seam, carried dinosaur bones and was of Lance age, whereas the main portion, above the first coal, was of Fort Union age.

In 1928 McLearn extended his surveys eastward from the Cypress Hills area and made several important discoveries (McLearn, 1929). One of these was the erosional unconformity at the base of the "Lower Ravenscrag" (Frenchman) that may be seen along Frenchman River to cut out the Whitemud Formation and even the underlying "basal sandstone" (Eastend Formation). In the Wood Mountain and Willowbunch areas he recognized the position of the pseudo-Whitemud beds high in the Ravenscrag and showed that Davis's Estevan Formation was based on various parts of the Ravenscrag Formation. He recorded the widespread occurrence of dinosaur bones found by C. M. Sternberg in the "Lower Ravenscrag" and correlated these beds with the Lance and Hell Creek formations. His suggestion that the Upper Ravenscrag might be "the equivalent of the Tullock and other Paleocene formations of southern Montana" was prophetic of the present interpretation.

In 1929 McLearn (1930) clearly established the distinctness and the position of the upper kaolinized beds and named them the Willowbunch Member of the Ravenscrag Formation. While still retaining the Lancian equivalent as "Lower Ravenscrag", he recognized that the "Upper Ravenscrag" was divisible locally into a lower, grey or sombre facies and an upper, buff or yellowish facies. Extensive collecting permitted the first adequate listing of the Ravenscrag flora, as identified by E. W. Berry. McLearn's surveys of 1930 amplified the observations of 1928 and 1929. The subsequent report (McLearn, 1931) contains no new stratigraphic conclusions, being mainly concerned with the distribution of ceramic materials.

McLearn's observations on the Ravenscrag Formation were consolidated in a memoir on the geology of southern Saskatchewan, although his role as the major contributor was obscured by the alphabetical listing of the authors (Fraser et al., 1935). In addition to reviewing and expanding the descriptions of his earlier reports McLearn gave additional faunal and floral lists for the Ravenscrag and noted the resemblance of the "grey facies" to the Tullock and Lebo of Montana and the "buff facies" to the Tongue River.

McLearn had deliberately refrained from separating the Lancian, dinosaur-bearing beds from the Ravenscrag Formation, but Furnival (1946) proposed that they be excluded and designated the Frenchman Formation. In addition to being of Cretaceous rather than Tertiary age, the Frenchman can usually be defined at the top by the lowest Ravenscrag coal seam, and at the bottom by the pre-Lancian unconformity. Following Furnival's work, the name Ravenscrag has been restricted to the beds above and including the lowest coal seam. His report includes a number of detailed sections of Ravenscrag beds along the southern margin of the Cypress Hills.

In 1948 I made a structural survey of the Frenchman River valley from Eastend westward and published a detailed section of the Ravenscrag Formation at Ravenscrag Butte (Russell, 1949). This confirmed the analogy of the lower, grey Ravenscrag beds with the Ludlow, Tullock, and Lebo formations of the Fort Union Group, and that of the buff Ravenscrag beds with the Tongue River Formation, but no new dating was established. Subsequently I gave a summary of the distribution and the lithological characteristics of the Ravenscrag Formation, and restated the analogy with the Ludlow and Tongue River formations (Russell, 1953).

The most recent contribution to the Ravenscrag literature was by Byers (1969). This is a mineralogical study of the Eastend and Whitemud formations with comments on the composition and probable origin and deposition of the Ravenscrag sediments.

Materials and Methods

Field Work

I began collecting data for the present study in 1969 by re-examining the exposures of Ravenscrag and underlying beds near Willows east of Assiniboia, in Twelve Mile Lake valley from the lake east to St. Victor, and in Big Muddy Valley from Harptree to the uplands west of Big Muddy Lake. In 1970 I examined the Frenchman-Ravenscrag transition east of Morgan Creek, the grey to buff transition of the Ravenscrag from St. Victor to Willow Bunch, and the buff beds southwest and east of Rockglen. I also visited the badlands south of Fort Peck, Montana, to examine the upper Hell Creek and the Tullock beds and the occurrences of fossil mammals. Later I examined Tongue River and Sentinel Butte beds in the Yellowstone Valley east of Sidney, Montana, in the Missouri Valley from Trenton, North Dakota, to Snowden, Montana, and in the Big Muddy Valley from Plentywood to Redstone, Montana.

My observations on the Ravenscrag Formation in 1971 were confined to the southeast corner of the Cypress Hills, especially the newly discovered fossil locality in Pine Cree Park. In 1972 I returned to this area with additional assistants and prospected the exposures in Frenchman River valley from Eastend to Ravenscrag. We worked the fossil bed in Pine Cree Park intensively and measured stratigraphic intervals here and on Anxiety Butte. As in previous field seasons, vertical measurements were made with Abney hand-level and 10-foot rod or, where exact locations were required, with stadia-compass survey.

The principal aim of all of this field work was to relocate earlier-known fossil occurrences or to discover new ones, and to determine the stratigraphic position of the fossiliferous layers with reference to established horizons. The results of this field work, together with the study of the fossils in the laboratory, constitute the subject of the present report.

Stratigraphy

Detailed stratigraphic sections of the Ravenscrag Formation of southwestern Saskatchewan have been given by McLearn (in Fraser et al., 1935), Furnival (1946), and Russell (1949). For present purposes it is necessary only to describe the main features, particularly the important changes in the sequences and the principal horizon markers.

Most workers have taken as the type section the extensive exposures at Ravenscrag Butte (sect. 27, twp 6, rge 23, W. 3rd mer.). Here over 200 ft (60 m) of continuously exposed strata may be examined (Fig. 1A). Including the No. 1 (Ferris) seam at the base, there are four conspicuous beds of coal or coaly shale, No. 2 about 40 ft (12 m), No. 3 about 90 ft (27 m), and No. 4 about 125 ft (38 m) above the base. Below the No. 3 seam the beds are predominantly grey and grey-brown shale or clay, with some rusty-coloured, concretionary sandstone. This is the so-called grey facies. Above the No. 3 seam the predominant rock is a buff-coloured siltstone or fine sandstone, with lesser beds of grey or grey-buff clay and some lignitic shale. There are numerous well-preserved leaf impressions and some freshwater mollusc shells in the grey beds.

About 12 miles (19 km) to the northeast there is an incomplete exposure of the formation on Anxiety Butte (Fig. 1B), a promontory on the escarpment of the Cypress Hills (sect. 28, twp 7, rge 21, W. 3rd mer.). Although the lower beds are mostly concealed, the burned remnants of the No. 1 seam are conspicuous. The No. 2 seam is 55 ft (16.8 m) above the No. 1 seam, and the No. 3 seam is 75 ft (22.8 m) above. The last-named seam was formerly mined here. The change from the grey to the buff facies occurs about 60 ft (18 m) above the No. 3 seam. If this is the equivalent of the No. 3 seam at Ravenscrag Butte, the grey facies has thickened considerably in the intervening distance. The No. 3 seam of Anxiety Butte was also worked extensively on the valley side northwest of Southfork village. By instrumental survey the Pine Cree Park fossil locality (see below) is topographically 45 ft (13.8 m) higher than this coal seam.

The next significant exposure of Ravenscrag beds is on the north slope of the Wood Mountain plateau, south of the village of Fir Mountain (Gwendella Valley section of McLearn; Fig. 1C herewith). Here the transition from the grey to the buff facies is about 165 ft (50 m) above the No. 1 coal seam, indicating further thickening of the grey facies as compared with the Anxiety Butte section. Here also is exposed the Willowbunch Member of the buff facies, kaolinized sand and clay about 400 ft (120 m) above the No. 1 coal seam, but closely resembling the Whitemud Formation, which is 20 ft (6 m) or more below that seam.

In the Morgan Creek badlands southwest of the village of Killdeer most of the extensive exposure is of the Frenchman Formation (Lancian), but the No. 1 coal seam is present, and on the escarpment on the southeast margin (sect. 7, twp 1, rge 4, W. 3rd mer.) the transition from Frenchman to Ravenscrag is well exposed. The following is a typical section here:

Prairie level	
Sandstone, fine-grained, soft, buff to rusty buff, with some bentonitic clay and a thin bed of lignitic clay	+35 ft (11 m)
Shale, lignitic, black, weathering flaky	10 ft (3 m)
Clay, bentonitic, grey and brown (Frenchman by definition but no dinosaur bones)	50 ft (16 m)
Shale, lignitic	1 ft (0.3 m)
Clay, bentonitic, grey and brownish grey, with lenses of buff to rusty buff soft sandstone, partly indurated; dinosaur bones in lower part	+100 ft (30 m)

Ravenscrag beds adjacent to the grey-buff transition are exposed in Twelve Mile Lake Valley from the lake eastward to Willow Bunch. Northeast of St. Victor (NE¼, sect. 5, twp 6, rge 29, W. 2nd mer.) there is a thick lens of white, tuffaceous and bentonitic clay and sandstone, which McLearn placed at the base of the buff facies.

High beds of the buff facies, including the Willowbunch Member, appear again in the same valley southeast of Willow Bunch town (Fig. 1D). Here the grey-buff transition has risen to within 165 ft (49 m) of the Willowbunch Member. The situation here is confused by the presence of a second kaolinized member 40 ft (12 m) higher in the section.

A complete section of the Ravenscrag Formation can be compiled from exposures in Big Muddy Valley and the uplands southwest of Big Muddy Lake (Fig. 1E). No dinosaur remains have been found beneath the No. 1 coal seam, which rests almost directly on the Whitemud clay, so that both the Frenchman and Battle formations are presumed to be absent here. The grey-buff transition lies about 240 ft (73 m) above the base of the formation and about 180 ft (55 m) below the Willowbunch Member.

That the No. 1 coal seam is essentially the same horizon across southwestern Saskatchewan is supported by the occurrence below it at most places of the dinosaur-bearing Frenchman or older beds, the absence of dinosaur bones, and the presence of Fort Union type plants and molluscs above it. If this is correct, the grey-buff transition is progressively higher from west to east, moving from about 90 ft (28 m) above the formational base at Ravenscrag Butte to about 240 ft (73 m) at Big Muddy Valley.

Localities

Invertebrate fossil occurrences in the Ravenscrag Formation were designated by McLearn (in Fraser et al., 1935, 127) by numbers from 1 to 26, with an appended list giving brief stratigraphic data and geographic location. However, designation of fossil localities by arbitrary numbers is less satisfactory than by names, because names are easier to remember and can have geographic connotations. Also, a simple typographic error in a number can make it completely erroneous, whereas in a name it can usually be recognized as such and disregarded. The difficulty with place names is that in some areas, such as Big Muddy Valley, there are not enough to go around. In the following paragraphs and in the systematic descriptions names are used where possible, but in some areas a general name is used, followed by the appropriate McLearn number, e.g., Big Muddy 3.

Knollys. McLearn's locality 14; sect. 30, twp 6, rge 22, W. 3rd mer. This is the north side of Frenchman River valley, northwest of Knollys siding. Collection by McLearn, 1927. Said to be from the grey facies, but shells also occur here in the lower buff beds.

Calf Creek. McLearn's locality 13; GSC catalogued locality 21523; NE¼, sect. 5, twp 8, rge 22, W. 3rd mer. Left side of west branch of Calf Creek just above juncture with main branch. McLearn said "Grey facies" but the occurrence is near the local top of the formation. Fossils are abundant in a dark friable clay. Permission to visit this locality should be obtained from Mr. William White. Collections by F. H. McLearn, 1927, and E. T. Tozer, 1951.

Chimney Coulee. GSC catalogued locality 21527; NE¼, sect. 17, twp 7, rge 21, W. 3rd mer. This was an open-pit coal mine, presumably on the No. 3 seam, but has now largely fallen in. It was discovered as a fossil site by H. S. Jones of Eastend, who showed it to me. Main collection was by E. T. Tozer, 1951. Chimney Coulee got its name from the stone chimneys that stood for some years after the disappearance of the log cabins that housed the original North-West Mounted Police post of East End.

Pine Cree Park. Near the SW corner of sect. 2, twp 8, rge 21, W. 3rd mer., about two miles northwest of Southfork village. Pine Cree Park is a community park, and permission to do extensive collecting here should be obtained from the Chairman, Regional Parks Authority, Shaunavon, Sask. The name Pine Cree is official, but according to Mr. H. S. Jones of Eastend it is a corruption of Pine Creek, which in turn was misnamed for the extensive stands of spruce in the vicinity. The name has also been applied informally to an occurrence of Oligocene mammals in road cuts in the SW¼, sect. 2, twp 8, rge 21, W. 3rd mer. In a forthcoming account of the mammals of the Cypress Hills Formation I shall formally designate this latter Oligocene occurrence as the Southfork locality.

The Pine Cree Park locality is a small cutbank on the east side of the creek, near the south boundary of the park. The following section was measured here by hand level:

Gravel, reworked Cypress Hills beds	
Shale, friable, crumbly, grey and buff; occasional leaf impressions	+15 ft (4.5 m)
Sandstone, clayey, soft, rusty-coloured; numerous crushed shells, with fish scales and vertebrae and reptile and mammal teeth and bones	1.8 ft (0.55 m)
Sandstone, soft, clayey, massively bedded, buff-coloured	+12 ft (3.7 m)

The strata associated with the fossil bed here resemble those of the buff facies, but the topographic position 45 ft (13.7 m) above the No. 3 coal seam indicates an upper part of the grey facies as compared with the section at Anxiety Butte. The strata at the Pine Cree Park locality have a slight dip to the south, which suggests slumping, but they could not have dropped far, and it may be concluded that the fossil bed is about 120 ft (37 m) above the base of the formation, and near the transition of the grey facies to the buff facies.

Harptree 8. McLearn's locality 8. NW¼, sect. 33, twp 3, rge 26, W. 2nd mer. South rim of Twelve Mile Lake valley south of Harptree village. In the Willowbunch Member. Collection by F. H. McLearn, 1929.

Harptree 9. McLearn's locality 9. Same location as Harptree 8 but from below the Willowbunch Member.

Big Muddy 2. McLearn's locality 2; NE¼, sect. 13, twp 3, rge 24, W. 2nd mer. South rim of Big Muddy Valley, east of Highway 34. Just above Willowbunch Member. Collection by F. H. McLearn, 1929.

Big Muddy 3. McLearn's locality 3; north side of sect. 18, twp 3, rge 23, W. 2nd mer. South side of Big Muddy Valley, east of Highway 34. Grey facies. Collection by F. H. McLearn, 1929.

Big Muddy 4. McLearn's locality 4; SE¼, sect. 26, twp 2, rge 22, W.

2nd mer. North of Big Muddy Lake. Grey facies. Collection by F. H. McLearn, 1929.

Big Muddy 5. McLearn's locality 5; sect. 3, twp 2, rge 22, W. 2nd mer. West side of valley, south of south end of Big Muddy Lake. About 150 ft (46 m) below Willowbunch Member, in buff facies. Collection by F. H. McLearn, 1929.

Big Muddy 6. McLearn's locality 6; SE¼, sect. 4, twp 2, rge 22, W. 2nd mer. Large isolated butte southwest of south end of Big Muddy Lake. Fossils occur in buff clayey sandstone about 30 ft (9 m) above Willowbunch white clay. Collection by F. H. McLearn, 1929.

Big Muddy 11. McLearn's locality 11; probably in sect. 12, twp 2, rge 22, W. 2nd mer. East side of valley, east of south end of Big Muddy Lake. Grey facies, over 100 ft (30 m) below Willowbunch Member. Collection by F. H. McLearn, 1929.

Big Muddy 12. McLearn's locality 12; sect. 1, twp 1, rge 22, W. 2nd mer. East side of Big Muddy Valley, near International Boundary. Buff facies, above Willowbunch Member. Collection by F. H. McLearn, 1929.

Big Muddy 16. McLearn's locality 16; probably in sect. 36, twp 1, rge 22, W. 2nd mer. Big Muddy Valley, east of Keogh ranch buildings. Buff facies just above Keogh coal seam. Collection by F. H. McLearn, 1929.

Big Muddy 17. McLearn's locality 17; sect. 1, twp 1, rge 22, W. 2nd mer. East side of Big Muddy Valley, near International Boundary. Buff facies, above Willowbunch Member. Collection by F. H. McLearn, 1929.

Big Muddy 18. McLearn's locality 18; same location as 17, but between 75 and 100 ft (23 and 30 m) above Willowbunch Member. Collection by F. H. McLearn, 1929.

Big Muddy 19. McLearn's locality 19; sect. 24, twp 1, rge 22, W. 2nd mer. Buff facies. Collection by F. H. McLearn, 1929.

Big Muddy 21. McLearn's locality 21; "south arm Big Muddy lake". Buff facies. Collection by F. H. McLearn, 1929.

Big Muddy 22. McLearn's locality 22; sect. 12, twp 1, rge 22, W. 2nd mer. East side Big Muddy Valley. Buff facies. Collection by F. H. McLearn, 1929.

Big Muddy 23. McLearn's locality 23; NW¼, sect. 7, twp 2, rge 22, W. 2nd mer. McLearn's field labels refer to this locality by his survey station number: 2787. Isolated butte overlooking southwest side of Big Muddy Lake. Rich shell bed at base of buff, cliff-forming sandstone, above Willowbunch Member. Collections by F. H. McLearn, 1929 and 1930.

Big Muddy 24. McLearn's locality 24. Same location as 23, just over Willowbunch Member. Collection by F. H. McLearn, 1929.

Isolated occurrences of fossil vertebrates are listed with the systemative descriptions.

Abbreviations

Note—the following abbreviations are used with catalogue numbers, etc., to indicate the institution or collection concerned: GSC, Geological Survey of Canada, Ottawa, palaeontological collection; NMC, National Museum of Natural Sciences, National Museums of Canada, Ottawa, Palaeontology Division; ROM(IP), Royal Ontario Museum, Toronto, Department of Invertebrate Palaeontology; ROM(VP), Royal Ontario Museum, Department of Vertebrate Palaeontology; UADG, University of Alberta, Edmonton, Department of Geology; USNM, Museum of Natural History, Washington, Department of Paleobiology.

Systematic Description

Phylum Mollusca
Class Pelecypoda
Order Unionoida Stoliczka, 1871
Family Unionidae Fleming, 1828

Plesielliptio Russell 1934

GENERIC DIAGNOSIS
Shell of medium size, narrowly to broadly ovoid. Beaks sculptured with a few fine, close-set plications, concentric or double-looped; two slightly divergent, straight or gently curved lines directed posteroventrad from beak apex. No posterior radiating ornamentation. Dentition similar to that of *Elliptio* Rafinesque.

Plesielliptio priscus (Meek and Hayden)

Fig. 2A

Unio priscus Meek and Hayden, 1857: 117; Meek, 1876: 516, pl. 43, figs. 8a-8d; White, 1883: 432, pl. 14, fig. 1; Henderson, 1935: 89, 90.
Elliptio (Plesielliptio) priscus, Russell, 1934: 3.
Plesielliptio priscus, Tozer, 1956: 40, 41, pl. 2, figs. 1, 2.

TYPE. USNM 2162; Yellowstone River valley, 40 miles above the mouth, Richland County, Montana; Fort Union Group, Tongue River or Sentinel Butte formation.

OCCURRENCES
Calf Creek; Chimney Coulee; Big Muddy 16. Also reported by McLearn from Willow Bunch.

SPECIFIC DIAGNOSIS
Shell medium-sized to rather large, ovoid in outline, moderately compressed. Beaks ornamented by six or seven fine plications parallel to growth lines, these plications traversed posteriorly by two nearly straight and slightly divergent lines, which approach but do not reach the posteroventral extremity of shell. Dorsal and ventral margins of shell broadly convex; anterior extremity broadly rounded; posterior extremity narrowly rounded, sometimes with oblique truncation. Length of type, 70.6 mm; height, 41.5 mm.

REMARKS
This species appears to be characteristic of the Paleocene, the supposed Cretaceous occurrences being either misidentifications, or correct identifications from rocks erroneously dated. In Alberta it occurs in the Paskapoo Formation and in the upper parts of the Saunders Formation and the Willow Creek Formation. Well-preserved specimens are present in the Ravenscrag Formation in the Roche Percée area of Saskatchewan. The species occurs in the Tongue River and Sentinel Butte formations of east-

ern Montana and adjacent North Dakota, and is probably present in the Polecat Bench Formation of the Bighorn Basin, Wyoming.

***Rhabdotophorus* Russell 1935**

GENERIC DIAGNOSIS

Shell ovoid, more or less elongate. Beaks well in advance of midlength; plications absent or vestigial. Postumbonal slope with a series of fine, curved costae, sweeping posterad and dorsad, interrupted by the more emphasized lines of growth. Hinge plate narrow; two wedge-shaped pseudocardinal teeth on left valve; one peg-like pseudocardinal on right valve; lateral teeth slender and posteriorly placed, probably two on left and one on right valve. Anterior adductor scar with dendritic pattern.

***Rhabdotophorus declivis* (Russell)**

Medionidus? senectus declivis, Russell, 1934b: 129, 130, fig. 3.
Rhabdotophorus senectus declivis, Tozer, 1956: 42.

TYPE. USNM 75288; Porcupine Butte, SE¼, sect. 10, twp 5N, rge 13E, Sweetgrass County, Montana.

OCCURRENCES

Reported by McLearn from Big Muddy 17 ("*Medionidus? senectus*").

SPECIFIC DIAGNOSIS

Shell elongate-ovoid, more or less tapering posteriorly; dorsal margin broadly convex, sloping to the narrowly rounded posteroventral extremity. Postumbonal area with fan of diverging costae, curving posterad and dorsad, but less distinct than in other species of the genus. Occasional specimens show vestigial *Plesielliptio*-like ornamentation of the umbo. Length of type, 76.4 mm; height, 41.2 mm; thickness as preserved, 16.8 mm.

REMARKS

This species has been treated previously as a "variety" of *Rhabdotophorus senectus* (White), which occurs in the Judithian formations of Montana and Alberta. The Paleocene forms are consistently more slender and have a more narrowly rounded posterior extremity. Only well-preserved and undistorted specimens show these distinctive features, but as a working hypothesis it may be assumed that *R. declivis* is characteristic of the Paleocene formations and *R. senectus* of the Judithian Cretaceous.

***Fusconaia* Simpson 1900**

GENERIC DIAGNOSIS

Shell short and high, relatively inflated for a unionid; outline broadly ovoid or subcircular, with posteroventral extremity more narrowly rounded than other parts of outline. Beaks anteriorly placed, pointing anterodorsad, smooth or with obscure concentric sculpture. Disc marked by growth lines, and by a more or less distinct ridge directed posteroventrad from beak; in some species a distinct depression anteroventral to this ridge, producing a shallow concavity on the posteroventral margin. Pseudocardinal teeth robust.

Fusconaia tuchiasana (Russell)

Fig. 2B

Unio tuchiasanus, Russell, 1932: 341, 342, pl. 1, figs. 4-6;
Fusconaia tuchiasana, Russell, 1934a: 1.

TYPE. GSC 6767, incomplete right and left valves; Ravenscrag Formation, above Willowbunch Member; Big Muddy 17. Paratype: GSC 6768, nearly complete shell; Big Muddy 11.

SPECIFIC DIAGNOSIS
Shell broadly ovoid, slightly produced posteroventrad. Beaks moderately prominent. Postumbonal ridge broad and poorly defined; slight concavity of posteroventral margin. Pseudocardinals not robust, two on left valve, one on right. Length of paratype, 51.8 mm; height, 32.8 mm; width, 24.5 mm.

REMARKS
This species seems to fall within the shell characters of *Fusconaia* except for the low beaks and the weak dentition. I am unable to suggest a more plausible generic reference. No additional specimens of this species have been found in recent years.

Order Veneroidea
Family Sphaeriidae

Sphaerium Scopoli 1777

GENERIC DIAGNOSIS
Shell small, thin, rather convex, broadly ovoid and more or less equilateral in outline. Beaks inflated but not prominent, situated near mid-length. Dentition small and delicate; usually two cardinals on each valve; two anterior and posterior laterals on right valve, one of each on left. Surface marked by concentric growth lines.

Sphaerium formosum (Meek and Hayden)

Fig. 2C

Cyclas formosa, Meek and Hayden, 1857: 115.
Sphaerium formosum, Meek and Hayden, 1861: 185; Meek, 1876: 526, pl. 43, figs. 4a-4c; Henderson, 1935: 116; Tozer, 1956: 43, pl. 2, fig. 7.

TYPE. USNM 2125, both valves; probably Sentinel Butte Formation; Missouri River valley, 10 miles below Buford, North Dakota.

OCCURRENCES
Calf Creek. Not reported by McLearn.

SPECIFIC DIAGNOSIS

Shell small for the genus, moderately convex, inequilateral in outline. Beaks anteriorly placed and inclined slightly forward. Anterior dorsal margin slightly convex, and sloping; posterior dorsal margin nearly straight; ventral margin rounded, most prominent posteriorly; anterior extremity rounded; posterior extremity truncated more or less obliquely. Length of type, 4.0 mm; height, 3.4 mm; thickness, about 2.4 mm.

REMARKS

This tiny shell also occurs in the Paskapoo Formation and equivalent beds of Alberta. The species has been reported from the St. Mary River Formation of Alberta but Tozer (1956, 44) refers this occurrence to his *Sphaerium gietzi.*

Sphaerium fowleri **Russell**

Fig. 2D

Sphaerium fowleri Russell, 1931a: 11, 12, figs. 5-8; Tozer, 1956: 43, pl. 2, fig. 6.

TYPE. UADG Pa88, left valve; Paskapoo Formation; ls 11, sect. 32, twp 20, rge 28, W. 4th mer., Highwood River, Alberta.

OCCURRENCES

Calf Creek. Reported by McLearn from Big Muddy 3, 4, and 6.

SPECIFIC DIAGNOSIS

Shell medium-sized to large for the genus, moderately convex, broadly and equilaterally ovoid in outline. Beaks placed a little anterior to midlength. Dorsal margin broadly convex, nearly straight in front; ventral margin broadly convex; extremities rounded, anterior somewhat abruptly. Cardinal teeth relatively robust, first two close together and nearly vertical, third sloping posteroventrad; left anterior lateral tooth rather prominent. Length of type, 11.5 mm; height, 9.3 mm; original width about 6 mm.

REMARKS

The relatively large size and the broadly ovoid, equilateral outline distinguish this species readily from other late Cretaceous and early Tertiary sphaeriids of the region.

Class Gastropoda
Order Caenogastropoda Cox 1959
Family Hydrobiidae Simpson 1865

Hydrobia Hartmann 1821

GENERIC DIAGNOSIS

Shell small to minute, elongate-ovoid. Spire conoid. Aperture ovoid, simple. More or less umbilicate. Surface smooth or with growth lines. Operculum horny, with few volutions.

Hydrobia anthonyi (Meek and Hayden)

Fig. 2G,H

Melania Anthonyi Meek and Hayden, 1857: 124.
Hydrobia Anthonyi, Meek, 1876: 571, pl. 43, figs. 10a-10d.
Hydrobia anthonyi, Henderson, 1935: 195.

TYPE. USNM 2149; Yellowstone River valley, 30 miles above junction with Missouri River, Richland County, Montana; Tongue River or Sentinel Butte Formation.

OCCURRENCES
Calf Creek; Big Muddy 6.

SPECIFIC DIAGNOSIS
Shell very small; spire moderately elongate, pointed. Volutions five or six, regular, gently convex; last whorl rounding abruptly to base. Aperture obliquely ovoid, narrowly rounded in front and behind; inner lip a little expanded. Umbilicus slit-like. Surface marked by faint lines of growth. Length of holotype, 4.3 mm; width, 2.4 mm; length of aperture, 1.6 mm.

Hydrobia warrenana (Meek and Hayden)

Fig. 2I,J

Melania Warrenana Meek and Hayden, 1858: 137.
Hydrobia Warrenana, Meek, 1876: 572, pl. 43, figs. 11a-11c.
Hydrobia warrenana, Henderson, 1935: 199.

TYPE. USNM 2147; Fort Union Group, probably Tongue River Formation; Missouri River valley, 30 miles (48 km) below Fort Clark (near the present city of Bismark), North Dakota.

OCCURRENCES
Calf Creek; Pine Cree Park; Big Muddy 3.

SPECIFIC DIAGNOSIS
Shell small, slender. Spire elongate, pointed; volutions about seven, regular, slightly convex or flat; last whorl rounding abruptly to base. Aperture broadly and obliquely ovoid. Surface with faint lines of growth. Length of holotype, 7.1 mm; width, 3.5 mm; length of aperture, 2.4 mm.

REMARKS
This species may be distinguished readily from *H. anthonyi* by the more elongate spire and the less ovoid shape.

Family Viviparidae Gray

Viviparus Montfort 1810

GENERIC DIAGNOSIS
Shell of medium size, broadly conoid in shape, rather thin. Whorls convex

and usually without prominences. Aperture broadly ovoid; peristome entire, not much thickened. Operculum concentrically striated.

Viviparus leai (Meek and Hayden)

Fig. 2K,L

Paludina Leai Meek and Hayden, 1857: 121.
Vivipara Leai, Meek and Hayden, 1861a: 185.
Viviparus Leai, Meek, 1876: 577, pl. 44, figs. 6a-6d.
Viviparus leai, Henderson, 1935: 169; Tozer, 1956: 51, 52, pl. 4, figs. 4a-6.

TYPE. USNM 2154; Fort Union Group, probably Tongue River Formation; Missouri River valley near Fort Clark, North Dakota.

OCCURRENCES

Big Muddy 23; doubtfully at Big Muddy 16.

SPECIFIC DIAGNOSIS

Shell of medium size for the genus. Spire moderately elongate; volutions about five, convex; last whorl faintly flattened at periphery and rounded abruptly to base. Aperture rather broad; inner lip slightly reflected. Umbilicus very small. Surface marked by numerous lines of growth, fine revolving striae, and on typical specimens revolving rows of minute pits. Length of holotype, 25 mm; width, 20.5 mm; length of aperture, 14.0 mm.

REMARKS

This is one of the most widely distributed of Paleocene gastropods, ranging from central North Dakota to north-central Alberta. It has been reported from the "Laramie" of Colorado and the "Fort Union" of Wyoming.

Viviparus retusus (Meek and Hayden)

Paludina retusa Meek and Hayden, 1857: 122.
Vivipara retusa, Meek and Hayden, 1861a: 185.
Viviparus retusus, Meek, 1876: 578, pl. 44, figs. 5a-5f; Henderson, 1935: 174; Tozer, 1956: 56, 57, pl. 4, figs. 1, 2.

TYPE. USNM 2155; probably Tongue River Formation; locality according to Meek (1876), "Three miles below Fort Clarke, Dakota", but label reads, "mouth of Yellowstone River, North Dakota".

OCCURRENCES

Reported by McLearn from Willow Bunch, Harptree 8 and 9, and Big Muddy 4 and 5.

SPECIFIC DIAGNOSIS

Shell of medium size for the genus, rounded-conoid in shape. Spire moderately elongate, obtusely rounded at apex; volutions about five, moderately convex; last whorl more or less flattened, and either rounded or subangular at periphery. Aperture broad; outer lip retractively oblique; inner lip a little reflected. Umbilicus closed. Surface marked by numerous lines of growth, retractively oblique and parallel to outer lip, and on some specimens by a few revolving striae. Length of holotype, 27 mm; width, 22.5 mm; length of aperture, 17 mm.

REMARKS

This species is almost as widely distributed in the Paleocene as is *Viviparus leai,* from which it is readily distinguished by the rounded apex.

Viviparus trochiformis (Meek and Hayden)

Fig. 3A,B

Paludina trochiformis Meek and Hayden, 1857: 122, 123.
Vivipara trochiformis, Meek and Hayden, 1861a: 185.
Viviparus trochiformis, Meek, 1876: 580-582, pl. 44, figs. 2a-2c; Henderson, 1935: 174-176; Tozer, 1956: 58, pl. 4, fig. 3.

TYPE. USNM 2158; Fort Union Group, probably Sentinel Butte Formation; Missouri River valley, "ten miles below Fort Union, Montana". This location would be in North Dakota, southwest of Williston.

OCCURRENCES

Big Muddy 17 and 23; reported by McLearn from Big Muddy 6 and 11, and from Calf Creek. In Montana I collected well-preserved specimens of this species 70 feet above base of the Sentinel Butte Formation, in SE¼, sect. 9, twp 22N, rge 53E, Richland County.

SPECIFIC DIAGNOSIS

Shell medium-sized for the genus, conoid. Spire moderately elongate, pointed; volutions five or six, gently convex to nearly flat; last whorl usually with a rounded shoulder and subangular or keeled periphery. Aperture broad, somewhat rhombic in outline. Umbilicus nearly closed. Surface marked by lines of growth and by two revolving ridges near midlength of whorl, most prominent on the penultimate whorl, but in some specimens fading out towards the aperture; very fine revolving lines also visible on some specimens. Length of holotype, 21.5 mm; width, 17 mm; length of aperture, 11.2 mm.

REMARKS

The prominence of the revolving ridges varies among specimens from the same occurrence. One assemblage from the Paskapoo Formation includes shells with irregular plications parallel to the growth lines.

Viviparus leidyi (Meek and Hayden)

Fig. 3C,D

Paludina Leidyi Meek and Hayden, 1857: 123.
Viviparus Leidyi, Meek, 1876: 582, 583, pl. 44, fig. 4.
Viviparus leidyi leidyi, Henderson, 1935: 169, 170.

TYPE. USNM 12476; Fort Union Group, probably Sentinel Butte Formation; Missouri River valley, "Ten miles below Fort Union, Dakota", i.e., southwest of Williston, North Dakota.

OCCURRENCES
Big Muddy 11 and 23; reported by McLearn from Big Muddy 2.

SPECIFIC DIAGNOSIS
Shell large for the genus. Spire elongate, pointed; volutions six or seven, convex, especially the later whorls, with rounded shoulder and impressed suture; body whorl may be slightly flattened near aperture, with a subangular periphery. Aperture broadly ovoid or subquadrate, angulate behind. Surface marked by lines of growth and very fine revolving striae; third and fourth whorls usually with a pair of poorly defined revolving ridges. Length of holotype as preserved, 45.3 mm; width, 30.8 mm; length of aperture, 20.9 mm.

REMARKS
This species can be distinguished from *V. trochiformis* by the larger size, more convex whorls, and poor development of the revolving ridges.

Viviparus formosus Meek

Fig. 3E,F

Viviparus Leidyi, var. *formosus,* Meek 1876: pl. 44, figs 3a, 3b.
Viviparus leidyi formosus, Henderson, 1835: 170.

TYPE. USNM 2159; Fort Union Group, probably Tongue River Formation; Yellowstone River valley near junction with the Missouri.

OCCURRENCES
Calf Creek; Chimney Coulee; Big Muddy 12, 22, and 23; reported by McLearn from Knollys, and from Big Muddy 6, 11, 17.

SPECIFIC DIAGNOSIS
Shell rather large for the genus, conoid. Spire pointed; volutions about five; external surface of whorls nearly flat; body whorl angulate at periphery; suture little impressed. Aperture broadly ovoid or subquadrate. Surface marked by lines of growth, fine revolving striae, and two or more revolving ridges. Length of holotype, 40 mm; width, 38.8 mm; length of aperture, 20.2 mm.

REMARKS
Viviparus trochiformis, V. leidyi, and *V. formosus* are closely related and often occur associated, but *V. formosus* seems as much entitled to specific rank as does *V. leidyi.* The most distinctive feature of *V. formosus* is the flattened exterior of the whorls, giving an even more trochiform shape than in *V. trochiformis.*

Campeloma Rafinesque 1819

GENERIC DIAGNOSIS
Shell ovoid in shape, heavy. Spire more elongate than in *Viviparus*; whorls

convex or shouldered. Aperture ovoid; inner lip with callus. No umbilicus. Operculum concentrically striated.

Campeloma nebrascense whitei Russell

Fig. 4A

Campeloma multilineata var., White, 1883: 469, pl. 27, figs. 5-7.
Campeloma nebrascensis, var. *whitei* Russell, 1931a: 12, 13, pl. 2, fig. 1.
Campeloma nebrascensis whitei, Henderson, 1935: 183; Tozer, 1956: 61, pl. 5, fig. 10.

TYPE. USNM 8139 (original of White's fig. 5); Fort Union Group; Yellowstone River valley, Montana.

OCCURRENCES
Chimney Coulee; Big Muddy 16. Reported by McLearn from Calf Creek, Willow Bunch, Big Muddy 3, 11, and 13.

SUBSPECIFIC DIAGNOSIS
Shell larger than in *C. nebrascense nebrascense.* Spire elongate, with obtuse apex; volutions about five, flattened, last two with prominent shoulder in front of suture, and revolving sinus in front of shoulder. Aperture subelliptical, rounded in front, angulate behind. Surface marked by irregular lines of growth and some revolving striae. Length of paratype (UADG Pa90), 25.1 mm; width, 15.4 mm; length of aperture, 12.4 mm.

REMARKS
As shown by White (1883), *Campeloma nebrascense* (Meek and Hayden) includes shells with convex whorls and a reticulation of growth lines and revolving striae, and shells with flattened, relatively plain whorls, with distinct shoulder and sinus. The former was distinguished by me (Russell, 1931b) as *C. nebrascense reticulatum,* but this may be merely the mature form of *C. nebrascense nebrascense.* As pointed out by Tozer (1956), the reticulate form occurs in Canada only in the Ravenscrag Formation of the Estevan area, southeastern Saskatchewan.

Lioplacodes Meek 1864

GENERIC DIAGNOSIS
Shell small and attenuated for a viviparid. Spire elongate, pointed; whorls gently convex to flat, suture little impressed. Aperture narrowly ovoid, acutely angulate behind; umbilicus nearly or completely closed by inner lip. Upper Jurassic to Paleocene.

Lioplacodes nebrascensis (Meek and Hayden)

Figs. 2M; 3I,J; 4C,D

Melania nebrascensis Meek and Hayden, 1857: 124, 125.
Goniobasis nebrascensis, Meek, 1876: 565, 566, pl. 43, figs. 12a-12h; Yen, 1948: 42, pl. 10, fig. 9.

Lioplax nebrascensis, Russell, 1931: 13, 14, pl. 2, figs. 2-5; Henderson, 1935: 185, 186.
Lioplacodes nebrascensis, Yen, 1946: 44; Tozer, 1956: 63, 64, pl. 6, figs. 17-19.

TYPE. Original type specimen apparently lost. Hypotypes: USNM 2138, Fort Union Group, Missouri River valley near Fort Clark, North Dakota; USNM 2139 and 2160, Tongue River or Sentinel Butte Formation, Yellowstone River valley near junction with the Missouri, McKenzie County, North Dakota.

OCCURRENCES

Chimney Coulee; Pine Cree Park; Big Muddy 12 and 23. Reported by McLearn from Calf Creek and Big Muddy 6 and 11.

SPECIFIC DIAGNOSIS

Shell medium-sized for the genus. Spire moderately elongate, pointed; volutions six or seven; external surface slightly convex; last two whorls somewhat prominent at midlength of whorl, with a flattened area or slight sinus just behind. Aperture acutely angulate behind; outer lip slightly sinuous in side view; inner lip may or may not completely close umbilicus. Surface marked by numerous slightly sinuous lines of growth, fine revolving striae, and in many specimens, two or more delicate revolving ridges near midlength of whorls. Length of a hypotype, 19.5 mm; width, 10.8 mm; length of aperture, 9 mm.

REMARKS

The nomenclatural history of this species is complex, as indicated by the references. The resemblance to the pleurocerid genus *Goniobasis* is noticeable, but the reference to *Lioplacodes* is based on the intergradation of the typical *L. nebrascensis* as described above with *L. nebrascensis producta* (White). Shells of the latter are larger, with more elongate spire, and flat, slightly shouldered whorls. Tozer (1956) stated that the complete transition from *L. n. nebrascensis* to *L. n. producta* does not occur in assemblages from single proveniences, but such an associated transition does occur in Ravenscrag beds near Eagle Butte, Alberta.

This is another widespread Paleocene species, the supposed occurrences in Upper Cretaceous rocks being either incorrect or subject to question.

Lioplacodes limnaeiformis **(Meek and Hayden)**

Fig. 3G,H

Bulimus limnaeiformis Meek and Hayden, 1857: 118.
Thaumastus limnaeiformis, Meek, 1876: 553, 554, pl. 44, figs. 8a-8d.
Campeloma limnaeiformis, Russell, 1929: 81, pl. 1, figs. 1-3; Henderson, 1935: 179, 180.
Lioplacodes limnaeiformis, Yen, 1946: 43, 44, pl. 1, figs. 4a, 4b; Tozer, 1956: 62, 63, pl. 6, figs. 1-8.

TYPE. USNM 2111; Fort Union Group, probably Tongue River Formation; Missouri River valley opposite mouth of Yellowstone River, Williams County, North Dakota.

OCCURRENCES

Calf Creek. Reported by McLearn from Willow Bunch, Harptree 9, Big Muddy 3 and 6.

SPECIFIC DIAGNOSIS

Shell medium-sized for the genus, elongate. Spire slender, apex blunt; volutions five to seven, slightly convex, faintly shouldered. Aperture narrowly and obliquely ovoid; umbilicus usually a minute slit at anterior end of labial callus. Surface marked only by slightly sinuous lines of growth. Length of holotype (immature specimen), 12.8 mm; width, 7.0 mm; length of aperture, 6.8 mm. Length of a large specimen, 23.5 mm; width, 9.7 mm; length of aperture, 11.2 mm.

REMARKS

This is a common Paleocene species, but it is also reported from uppermost Cretaceous formations. The supposed subspecies in the Edmonton Formation, *L. limnaeiformis tenuis* (Warren) was described as a small, very slender form, but Tozer (1956) considered it to be indistinguishable morphologically.

***Lioplacodes tenuicarinata* (Meek and Hayden)**

Fig. 4G,H

Melania tenuicarinata Meek and Hayden, 1958: 137.
Goniobasis tenuicarinata, Meek, 1876: 566, 567, pl. 43, figs. 14a-14c; Henderson, 1935: 228-230.
Lioplacodes tenuicarinata, Yen, 1948: 41, pl. 10, figs. 7-7d; Tozer, 1956: 66, 67, pl. 6, figs. 15a, 15b, 16a, 16b.

TYPE. USNM 2141; Fort Union Group, probably Tongue River; Missouri River valley near Buford, Williams County, North Dakota.

OCCURRENCES

Doubtfully reported by McLearn from Knollys, but this occurrence can now be confirmed.

SPECIFIC DIAGNOSIS

Shell small to medium-sized for the genus. Spire elongate, pointed; volutions six to seven, convex, flattened obliquely behind midlength of each whorl. Aperture somewhat produced in front. Surface, except that of first two or three whorls, marked by numerous sinuous lines of growth, fine revolving striae, and three or more distinct revolving ridges on the anterior half of each whorl, most prominent at midlength and progressively less marked toward anterior suture. Length of holotype, 13.4 mm; width, 7.4 mm; length of aperture, 5.8 mm. Length of a large specimen, 26 mm; width, 12.2 mm; length of aperture, 10 mm.

Order Pulmonata
Family Physidae

Physa Draparnaud 1801

GENERIC DIAGNOSIS
Shell medium-sized to small, sinistral, thin, elongate-ovoid. Spire acute, short to elongate; whorls convex, usually smooth. Aperture ovoid, rounded and somewhat produced in front; outer lip thin or with an internal thickening. Columella folded.

Physa canadensis Whiteaves
Figs. 4I,J; 5A,B

Physa copei, var. *canadensis* Whiteaves, 1885: 14, pl. 2, figs. 5-5b.
Physa canadensis, Russell, 1926: 215-218, pl. 2, figs. 3-8; Clench, 1937: 143, 144; Tozer, 1956: 75, 76.

TYPE. GSC 5529a; St. Mary River Formation (Upper Cretaceous); Pincher Creek, 1s. 4, sect. 22, twp 6, rge 30, W. 4th mer., Alberta.

OCCURRENCES
Big Muddy 23.

SPECIFIC DIAGNOSIS
Shell medium-sized to large for the genus. Spire varies from short to elongate, but never equals body whorl in length. Volutions six or seven; body whorl more or less inflated, slightly shouldered. Aperture narrowly ovoid or semi-ovoid; inner lip with broad callus. Length of holotype, 39.2 mm; width, 20.5 mm; length of aperture, 25.3 mm.

REMARKS
This species certainly crossed the Cretaceous-Tertiary boundary, as specimens from the St. Mary River and Paskapoo formations show the same characters and the same variations. These variants were formerly designated by me (Russell, 1926) as varieties, and redefined by Clench (1937), but Tozer (1956) interpreted them as intraspecific variations. They involve the length of the spire, from short to very long, and the shape of the body whorl, from inflated to attenuated.

Family Ancylidae

Ferrissia Walker 1903

GENERIC DIAGNOSIS
Shell small, thin, patelliform, ovoid or oblong, somewhat elevated; apex located posteriorly and a little to one side. Surface smooth or radially striate.

Ferrissia minuta (Meek and Hayden)

Valletia (Ancylus) minuta Meek and Hayden, 1857: 120.
Ancylus (Acroloxus) minuta, Meek and Hayden, 1861b: 432.
Acroloxus minutus, Meek, 1876: 543, 544, pl. 44, fig. 10.
Ferrissia? minuta, Henderson, 1935: 266, 267.
Ferrissia minuta, Yen, 1948: 42, pl. 10, fig. 14; Tozer, 1956: 76.

TYPE. USNM 2136; Tongue River or Sentinel Butte formation; Missouri River valley, three miles below Buford, Williams County, North Dakota.

OCCURRENCE
Reported by McLearn from Big Muddy 6.

SPECIFIC DIAGNOSIS
Shell ovoid, a little expanded anteriorly. Apex moderately prominent, situated a little to the left, and directed posterolaterad. Anterior slope gently convex; posterior slope slightly concave. Surface marked by very fine concentric striae. Length of holotype, 3.2 mm; width, 2.7 mm; height, 0.9 mm.

REMARKS
Whiteaves (1885, p. 17) referred ancylid shells from the St. Mary River Formation of Alberta to this species, but Tozer (1956) concluded that they were distinguishable from the typical *F. minuta* that occurs in the Fort Union and Paskapoo. The specimen from the Ravenscrag Formation is also typical of the species, so it appears that *F. minuta* is restricted to the Paleocene.

Ferrissia minuta falls within the subgenus *Laevapex* Walker, distinguished by the absence of radiating striae. A species that does have radiating striae, *Ferrissia radiatula* (Whiteaves, 1885), occurs in the Paskapoo Formation of Alberta.

Phylum Chordata
Class Osteichthyes
Order Acipenseriformes
Family Acipenseridae?

Genus and species undetermined

REFERRED SPECIMEN
Fragment of pectoral fin ray; Pine Cree Park.

REMARKS
This fragment is about 29 mm long, slightly tapering, and compressed-trianguloid in cross section. The wide edge is deeply channelled, and there are low, bifurcating ridges on each side. The reference to the Acipenseridae is based on the resemblance of this fragment to pectoral fin rays of *Acipenser* spp.

Order Semionotiformes
Family Lepisosteidae

Lepisosteus Lacepede 1803

GENERIC DIAGNOSIS

Elongate, slender fishes, with long, narrow jaws, bearing on each side a marginal row of small teeth, a submarginal row of large, sharp teeth, and an inner row or band of fine, rasp-like teeth. The large teeth of the submarginal row occlude in pits in the opposing jaw. Other characters, usually regarded as of family rank, should be noted. The tapering skull is sheathed in closely fitting bones, which have an external layer of enamel ornamented wtth radiating, finely nodose ridges. The scales are bony, with an external layer of enamel. They are arranged in oblique rows to form a closely imbricating cover for the entire body. The numerous flank scales (Fig. 2I-L) are rhomboid in shape, and are bevelled along the edges so as to overlap from above downwards and from in front backwards. There is a prolongation from the anterior angle, normally concealed by the scale in front. The scales of the dorsal midline (Fig. 2C,D) are symmetrically polygonal, broad near the head, narrowing towards the tail. The tail is heterocercal, and the dorsal and anal fins are close to the tail. The vertebrae are opisthocoelous.

Lepisosteus sp.
Fig. 5C-L

REFERRED SPECIMENS

Numerous scales, cranial fragments, and vertebrae from Calf Creek and Pine Cree Park; ROM.

REMARKS

The Ravenscrag scales have flat or slightly impressed enamel surfaces, with no radiating lines, but with fine pits, in some examples numerous and minute, in others relatively large and irregularly spaced. In these characters the scales differ from those of the modern *Lepisosteus osseus* (Linn.). In addition to the various scales, some cranial fragments and vertebrae from the Pine Cree Park locality are illustrated (Fig. 5E-H).

Order Amiiformes
Family Amiidae?

Genus and species undetermined

REFERRED SPECIMENS. Cranial fragments, palatal teeth, and vertebrae; Pine Cree Park; ROM(VP).

REMARKS

A few cranial fragments with irregular ornamentation are tentatively identified as amiid, as are some small vertebral centra that are ovoid rather than circular in outline. The small, blunt palatal teeth may represent the genus *Kindleia* Jordan (= *Stylomyleodon* Russell). For an account of this genus, see Estes (1964).

In addition to the many *Lepisosteus* scales from the Pine Cree Park locality, there are a few small, rectangular bony scales (Fig. 5M) that are reminiscent of the "ganoid" scales of the Paleoniscidae. One of the short sides is broadly notched internally to receive a pointed projection from the adjacent scale. The enamel surface has a pattern of rectangular growth lines. Such scales have been found at a number of localities in the Paskapoo Formation in association with the teeth of *Kindleia.* Although they are quite unlike the cycloid scales characteristic of the Amiidae, their persistent occurrence suggests that perhaps *Kindleia* was aberrant in its scale structure.

Class Reptilia
Order Testudinata Bonaparte, 1831
Family Emydidae Gray, 1825

Clemmys Ritgen 1828

GENERIC DIAGNOSIS

Carapace moderately arched and slightly keeled. Neurals six-sided, with greatest width near anterior end. Buttresses weak, just reaching lateral ends of costals, the inguinal buttress meeting the fifth costal. Plastron notched posteriorly. Triturating edge of jaws narrow and simple. Interorbital choanae present. (Based on Hay, 1908: 290.)

REMARKS

A more elaborate diagnosis of this genus, based largely on skull characters, was given by McDowell (1964: 276). That author restricted the genus to four North American species, and assigned the "Old-World" species formerly included in *Clemmys* to other genera in a separate subfamily, the Batagurinae. Most of the structures in which McDowell made this separation are cranial, and not applicable to the North American fossils assigned to *Clemmys.* Until cranial remains are found, it is practical to follow Hay's criteria and assign the fossil species to *Clemmys,* there being no geographical conflict with McDowell's conclusions.

Clemmys backmani Russell

Clemmys backmani Russell, 1934c: 107, 108, pl. 6, fig. 1.

TYPE. NMC 8685, an incomplete carapace; Ravenscrag Formation, near local base; ls 8, sect. 26, twp 3, rge 23, W. 2nd mer., north side of Big Muddy Valley. Collected by L. S. Russell, 1930.

SPECIFIC DIAGNOSIS

"Size large for the genus. Neurals normal in number (8), considerably longer than wide, except the 6th, which is shorter than wide. A second superpygal not certainly present. Inguinal buttress weak, just touching the 5th costal near its anterolateral angle. A slight median keel present on posterior half of carapace, especially on the 5th and 6th neurals, where it is bounded laterally by two shallow grooves." (Russell, 1934c: 107.)

REMARKS

Although additional species of *Clemmys* have been described since 1934, *Clemmys backmani* remains the most ancient occurrence of the genus, in either the broad or restricted sense.

Family Trionychidae Bonaparte 1838

Aspideretes Hay 1903

GENERIC DIAGNOSIS

Trionychid turtles with a preneural plate between nuchal and first neural. Eight pairs of costal plates, one or more pairs of which are in contact along the midline posterior to the last neural. (Based on Hay, 1908: 485.)

Aspideretes spp.

REMARKS

Turtle shell fragments showing the external pattern of irregularly arranged grooves and pits characteristic of the Trionychidae have been found at a number of localities in the Ravenscrag Formation. An incomplete carapace (NMC 8686) was described (Russell, 1934: 109, pl. 6, fig. 2), and compared with *Aspideretes subquadratus* Lambe. As that species is from the Oldman Formation (Judithian Cretaceous) of Alberta, it is unlikely that it is represented by the Ravenscrag specimen. The latter is from the NW¼, sect. 34, twp 3, rge 24, W. 2nd mer., on the north side of Big Muddy Valley. It was collected in 1930 by L. S. Russell as assistant to F. H. McLearn.

Order Crocodilia
Family Crocodylidae (Gray 1825) Hay 1902

Leidyosuchus Lambe 1908

GENERIC DIAGNOSIS

Medium-sized crocodiles, with moderately elongate-triangular skulls. Cranial segment short and relatively broad. Frontals forming part of anterior margin of superior temporal fenestrae. Anterior tip of nasals not quite, or just, reaching posterior margin of external narial opening. Posterior nares well within pterygoids, separated from posterior margin of these bones. Splenials participating in mandibular symphysis. First mandibular tooth fitting into closed pit on premaxilla; third and fourth mandibular teeth fitting into broad notch in external margin of premaxilla/maxilla; remaining teeth alternating, as in *Crocodylus*. Vertebrae procoelous.

REMARKS

This genus is currently under revision by W. Langston, Jr., and Michael Waldman. As a result of my own study of specimens and literature I am of the opinion that *Leidyosuchus gilmorei* Mook (1942) is a junior synonym of *L. canadensis* Lambe (1908), and that *L. multidentatus* Mook (1930), from the Torrejon fauna, is probably not a member of this genus.

Leidyosuchus acutidentatus Sternberg

Leidyosuchus acutidentatus Sternberg, 1932b

TYPE. NMC 8544, a nearly complete skull and mandible, with some post-cranial elements; Ravenscrag Formation, 60 ft (18 m) above the grey-buff transition; SW¼, sect. 31, twp 5, rge 28, W. 2nd mer., south side of Twelve Mile Lake valley, between St. Victor and Willow Bunch, Saskatchewan. Collected by C. M. Sternberg, 1929.

SPECIFIC DIAGNOSIS

Precranial portion of skull relatively long and slender. Anterior external margin of maxilla bulging moderately; concavity in the premaxilla/maxilla margin moderately developed. Anterior extremity of snout almost straight in outline. Fourth mandibular tooth very long.

REMARKS

The snout region of *L. acutidentatus* is much narrower than that of *L. canadensis* (Sternberg, 1932a), resembling that of *L. sternbergii* Gilmore (1910) from the Lance Formation of Wyoming. However, in relative elongation of the precranial region, *L. acutidentatus* exceeds both *L. sternbergii* and *L. canadensis.*

Isolated teeth, cranial fragments, vertebrae, and scutes of crocodiles occur in the Pine Cree Park fossil bed and in grey Ravenscrag beds in Big Muddy Valley east of Highway 34. These are tentatively identified as *Leidyosuchus?* sp.

Class Mammalia Linnaeus 1758
Order Condylarthra Cope 1881
Family Oxyclaenidae Scott 1892

REMARKS

Most recent students of early mammals have followed Matthew (1937: 38) in classing *Oxyclaenus* and its relatives as a subfamily Oxyclaeninae of the family Arctocyonidae Murray 1866. Although there are genera such as *Protogonodon* that are in some ways intermediate, the dental structure of the two groups shows diverse adaptations, the oxyclaenids for piercing and shearing, the arctocyonids for crushing. There is a close analogy here to the relationships between the Canidae and the Ursidae. It is generally agreed that the bears were derived from the dogs, and there are intermediate forms in the fossil record that have to be assigned somewhat arbitrarily to one family or the other. Similarly the arctocyonids were probably derived from the oxyclaenids, and intermediates are to be expected. However, the distinctive nature of the majority of the two groups makes a familial separation as logical as for the Canidae and Ursidae.

Carcinodon Scott 1892

GENERIC DIAGNOSIS

Size small for an oxyclaenid. Lower molars with M_1 slightly smaller than M_2, M_3 about as wide as M_2 but longer. Trigonids moderately high, short; talonids little if any wider than trigonids. Paraconids distinct, not as lingual as metaconids. P_4 with talonid slightly or not at all expanded buccad.

REMARKS

Matthew (1937: 57) questioned the validity of this genus, and there is no doubt that it is closely related to *Oxyclaenus* and *Loxolophus* of Cope. It differs from both of these genera in the nearly uniform width of the three lower molars and the lack of buccad expansion of the talonid, especially on M_2. The trigonids are higher than in *Loxolophus*.

Carcinodon aquilonius, n. sp.

Fig. 6A-D

ETYMOLOGY. Latin *aquilonius,* adj., northerly, of the north.

TYPE. ROM(VP) 12865, fragmentary left mandibular ramus, consisting of an anterior portion with P_2 and alveoli for P_1 and P_3, a dissociated P_4, a posterior portion with M_1, M_2, and the trigonid of M_3, and the articular condyle with a portion of the coronid process and the masseteric area; Pine Cree Park fossil bed; collected by L. S. Russell and party, 1972.

SPECIFIC DIAGNOSIS

Smaller than *C. filholianus* (Cope, 1888); paraconid more anterad-projecting; talonid of P_4 bulging slightly buccad.

DESCRIPTION

The P_1 is represented by a single alveolus, directed anterodorsad. The P_2 is a simple tooth, with a high protoconid, slightly convex in front, strongly concave behind. The talonid consists of a single, bluntly pointed cusp. There is a slight bulge at the anterior base of the crown, a faint rudiment of the anterior cusp ("paraconid") of more posterior premolars. The P_3 is represented only by the two alveoli, closely spaced, with a diastem between them and the P_2. The P_4 is larger and higher than the P_2; the protoconid is similar in shape but a little more robust. The talonid is wider than the protoconid, owing to a slight buccad bulge at the crown base. The posterior face of the protoconid and the buccal side of the talonid show the results of premortem wear, and the form of the hypoconid is obscured. In spite of these signs of wear, the position in which the roots of the P_4 fit the alveolar remnants of the two jaw fragments indicates that the tooth was not fully erupted at the time of death.

The M_1 is slightly smaller than the M_2, and the M_3 is almost as wide as the M_2, proportions similar to those of *Carcinodon filholianus* as described by Matthew (1937: 57). The trigonid of M_I is slightly narrower than the talonid, whereas on M_2 these parts are of about the same width. All trigonids are relatively high, the protoconid and metaconid being about equal, and slightly worn; these two cusps are opposite each other on M_I M_2, whereas the protoconid is slightly more anterior on M_3. The paraconids are lower than the two main trigonid cusps and project slightly anterad; the apex of the cusp is closer to the lingual margin than to the midline, but not as lingual as the metaconid. The posterior slope of the trigonid is flat, and inclined about 20° from the vertical. The talonids of M_I are basined, with the hypoconid the largest cusp and the entoconid and hypoconulid small and close together; the crista obliqua reaches the trigonid wall slightly buccad to midline. There are short cingula on the anterior face of the trigonid and on the buccal margin below the trigonid-talonid notch.

Dimensions of teeth: P_2 anteroposterior 3.1 mm, transverse 1.3 mm; P_4 anteroposterior 4.2 mm; transverse at protoconid 1.9 mm, at talonid 2.1 mm; M_I anteroposterior 4.2 mm, transverse 2.8 mm; M_2 anteroposterior 4.5 mm, transverse 3.2 mm; M_3 transverse 3.0 mm.

Of the two fragments of the mandibular bone, the posterior one shows no special features. The anterior fragment is slender and tapering and has a slightly concave ventral border. There is a small mental foramen directly below the anterior rim of the alveolus for P_2 and a larger posterior foramen below the anterior alveolus of P_3.

The third mandibular fragment lacks any contact with the other parts as preserved. It includes the condyle and parts of the posterior margin above and below. It is of about the same size as the corresponding part of the jaw in *Erinaceus europaeus* but slightly more robust. A portion of the rim of the dental foramen is present; it was evidently large.

REMARKS

If this specimen had been found in the Nacimiento Formation of New Mexico it would be referred to *Carcinodon filholianus* without much hesitancy. However, a geographic separation of over 1,000 miles makes it probable that the slight differences are of specific value, and the separation of the Ravenscrag specimen as a different species leaves the correlation a little more open.

Other species with which the present can be compared are *Oxyclaenus pearcei* Gazin (1941) from the Dragon fauna of Utah, and *Prothryptacodon albertensis* Fox (1968) from a well core in the Paskapoo Formation of Alberta. *O. pearcei* is larger than *C. aquilonius* but like the latter has anterad-projecting paraconids and the M_3 almost as wide as the M_2. *O. pearcei,* in fact, may be a species of *Carcinodon. P. albertensis* has about the same size and proportions as *C. aquilonius,* but the paraconids are not anterad-projecting.

The occurrence of the genus *Carcinodon* in the Pine Cree Park fossil bed indicates an Early Paleocene (Puercan) age for this part of the Ravenscrag Formation. At the youngest, the age might be that of the Dragon fauna (early Middle Paleocene).

Other Mammalian Remains

The hundreds of pounds of matrix from the Pine Cree Park fossil bed that have been washed, sifted, and searched have so far yielded no additional mammalian teeth. The most significant fossil found in this way is a small left calcaneum, ROM(VP) 12866. The size is about that of the calcaneum of Brewer's mole, *Parascalops breweri* (Bachman). The tuber calcis is nearly straight, wider in the vertical than the horizontal diameter, and truncated without expansion at the end. The distal end of the bone is flat and oblique, for articulation with the cuboid. There are two articular facets for the astragalus, one at the base of the tuber, facing anterad, and a larger one projecting from the mesial side and facing dorsad. These articular facets resemble those of the calcaneum in *Erinaceus europaeus.* A more distinctive feature of the Pine Cree Park specimen is the large, rounded peroneal tubercle on the lateral side near the distal end. Its apex is bluntly pointed and curved dorsad. This tubercle is found in a variety of mammals and seems to have little taxonomic significance. Thus it is moderately developed in *Loxolophus hyattianus* (Cope) (Matthew, 1937: fig 8) and prominent in *Claenodon ferox* (Cope) (Matthew, 1937:34). Of the more ungulate-like condylarths, *Meniscotherium* has it, and *Tetraclaenodon, Phenacodus,* and *Hyopsodus* lack it. Some creodonts have it (e.g. *Oxyaena*) and others do not (e.g. *Hyaenodon*). It is present in felids and absent in canids. In *Didelphis* it is present, but not at the distal end of the lateral surface. I am unable to assign the Pine Cree Park calcaneum to any particular mammalian order, but suggest that it may pertain to a small oxyclaenid. Length of the calcaneum parallel to its longitudinal axis is 5.1 mm and maximum width transverse to this is 2.7 mm.

Other bone fragments from the Pine Cree Park fossil bed that are identified as mammalian include the proximal end of a right femur, the distal end of a right tibia, and the distal end of a left metatarsal V. Comparative size indicates that three different mammals are represented. No taxonomic identification is attempted at this time.

Stratigraphic Correlation

As pointed out in the section on stratigraphy, the base of the Ravenscrag Formation in southwestern Saskatchewan is placed at the bottom of the lowest coal seam. That this is one continuous coal bed is doubtful, but it does seem to represent approximately the same time horizon throughout. A similar situation exists in the corresponding section in central Alberta and in northeastern Montana. It is a good working hypothesis that throughout this region the first coal seam above the beds with Lancian dinosaurs marks approximately the transition from Cretaceous to Tertiary time.

When the principal stratigraphic sections of the Ravenscrag Formation are compared (Fig. 1), using the lowest coal seam as the common datum, the most striking feature to appear is the increase in thickness of the grey facies from west to east, from 90 ft (27 m) at Ravenscrag Butte to about

240 ft (72 m) at Big Muddy Valley. It is evident, therefore, that the grey-buff contact transgresses time, and is not a horizon marker.

The numerous coal seams in the Ravenscrag Formation offer some opportunities for local stratigraphic correlation, but McLearn has shown that many of the seams pinch out laterally and others come in at lower or higher levels. Only if a seam can be traced continuously, or if it can be identified by its relationship to other horizons, can it be relied upon as a stratigraphic marker.

The Willowbunch Member in the buff facies is a conspicuous part of the section and because of its presumed origin from falls of volcanic dust can be assumed to be about the same age throughout. However, the presence of two kaolinized members near Harptree obscures the correlation value of the Willowbunch here. I follow McLearn (Fraser et al., 1935) in recognizing the upper "zone" as the Willowbunch Member because of its position relative to certain coal seams and to the grey-buff transition.

The Ravenscrag molluscan fauna appears to offer little aid in faunal zonation within the formation. Occurrences are more numerous in the eastern part of the region, from Willow Bunch to Big Muddy Lake. There are two parts of the section in which fossil molluscs are numerous, the lower in the strata adjacent to the grey-buff transition, and the other just above the Willowbunch Member. Despite the wide stratigraphic separation, most species occur in both parts.

Vertebrate occurrences in the Ravenscrag Formation are few and seem to be concentrated near the grey-buff transition. Fish and reptile remains are mostly of long-ranging taxa and are not very helpful for correlation either within or outside the region. The one known occurrence of fossil mammals is significant mainly because of its correlative value outside the region. It appears to represent the Puercan or earliest Paleocene fauna, known elsewhere from near Fort Peck, Montana, the Bighorn Basin of Wyoming, and the San Juan Basin of New Mexico. It would be most desirable to have mammalian fossils from the upper part of the Ravenscrag, to determine the time span of the formation.

The Ravenscrag Formation extends westward in the Cypress Hills to the western end of the upland. In an earlier interpretation of the stratigraphy of this interval (Russell, 1940) I postulated that the grey facies was replaced by the buff, and that in the Alberta end of the hills the Ravenscrag Formation consisted entirely of the buff facies. Furnival (1946), however, gives sections west of Ravenscrag Butte in which thicknesses of 100 feet or more are assigned to the grey facies. Massive sandstones low in these sections, regarded by me (op. cit.) as Ravenscrag, were assigned to the Frenchman Formation by Furnival, but there is no paleontological evidence for this. In the Eagle Butte area of Alberta the Lancian dinosaur fauna has been found by Mr. Luke Lindoe of Medicine Hat in a few feet of dark clay overlying unconformably the Battle and Whitemud formations. Although the basal coal seam appears to be absent here, the buff sandstone of Ravenscrag type lies conformably on the Lancian beds. These basal sandstones were also regarded by Furnival (op. cit.) as the westward extension of the Frenchman Formation, but his evidence is purely lithological, and in the absence of fossils I suggest that the beds above the dinosaur-bearing clay should all be regarded as Ravenscrag.

Somewhat pertinent to this question is the occurrence of well-preserved fossil molluscs in slumped basal Ravenscrag beds northwest of Eagle Butte (1s. 1, sect. 20, twp 8, rge 4, W. 4th mer.). The following faunal list is slightly revised from that previously published (Russell, 1940: 95).

"Unio" sp.
Sphaerium sp.
Hydrobia warrenana (Meek and Hayden)
Viviparus leai (Meek and Hayden)
Campeloma nebrascense whitei Russell
Lioplacodes nebrascensis producta (White)
Lioplacodes cypressensis (Dyer)
Lioplacodes limnaeiformis (Meek and Hayden)

All but one of these species *(Lioplacodes cypressensis)* are widespread in the Fort Union and other Paleocene formations of the northern plains. Only one *(Lioplacodes limnaeiformis)* has been found in Cretaceous rocks.

A collection of mammal teeth from the Ravenscrag Formation of the Cypress Hills in Alberta has been described by Krishtalka (1973). This is from the north escarpment, east of Elkwater Lake. The stratigraphic position is near the local top of the formation, so it is not surprising that the fauna indicates a Tiffanian or Late Paleocene age.

In southwestern Alberta the St. Mary River Formation contains in its upper part the equivalents of the Whitemud and Battle formations; above these, with an unconformity in places, are the grey and pink clays of the Willow Creek Formation. Dinosaur bones have been found in the lower part of the Willow Creek Formation, and Fort Union molluscs in the upper part. Presumably the latter is equivalent to some part of the Ravenscrag Formation.

The central Alberta section, extensively exposed in the valley of Red Deer River, has long been considered by the Geological Survey of Canada to terminate with the Edmonton Formation (Cretaceous), overlain unconformably by the Paskapoo Formation (Paleocene). The situation is more complex than this. In the upper part of the Edmonton Formation are the equivalents of the Whitemud and Battle formations, and unconformable above them the "Upper Edmonton" with a Lancian dinosaur fauna in the lower part. Recent revision of the stratigraphy here (Irish, 1970) elevated the Edmonton Formation to group status, to include the Battle, Whitemud, and Horseshoe Canyon (= Lower and Middle Edmonton) formations. The beds above the Battle were designated the Scollard Member and included in the Paskapoo Formation. These changes were intended in part to remove some of the difficulty in mapping the base of the Paskapoo Formation on the traditional criteria, i.e., massive basal sandstones.

It may well be that the upper part of Irish's (op. cit.) Scollard Member is of Paleocene age. The Ardley coal seam, which lies about 100 feet above the Battle Formation, appears to mark the upper limit of the Lancian dinosaur fauna (Sloan, 1969). The same situation may exist here as in southwestern Saskatchewan, where a coal seam marks the Cretaceous-Tertiary boundary. There are, however, two important differences. In Alberta, many thick coal seams occur below the Whitemud Formation, in the Horseshoe Canyon Formation of Irish (op. cit.). Also, there is deep channelling in places where the Paskapoo sandstones cut down hundreds of feet, eliminating the entire Scollard Member. Until diagnostic fossils are found above the Ardley coal seam I propose that the top of the Scollard be drawn at this seam. So as not to leave the post-Scollard, pre-Paskapoo beds in limbo, they should be mapped with the Paskapoo Formation but recognized as a distinct member.

Correlation of the Ravenscrag Formation eastward from southwestern Saskatchewan is made difficult by the absence of good exposures between Big Muddy Valley and the Souris River valley in the vicinity of Estevan and Roche Percée. In the latter area the natural exposures have been supplemented by extensive strip-mining for coal. This is near the centre of the Williston Basin, and wells drilled here have encountered the lowest coal seam between 600 and 700 ft (about 180 to 200 m) below the surface. As pointed out by McLearn (Fraser et al., 1935: 53), the Ravenscrag beds exposed here must be higher in the section than any still existing farther west in Saskatchewan. Evidence from fossils is not conclusive as yet. Well-preserved molluscs occur at several localities in the southern part of twp 1, rge 7, W. of 2nd mer. The following species are identified by me:

Plesielliptio priscus (Meek and Hayden)
Corbula mactriformis Meek and Hayden
Viviparus leai (Meek and Hayden)
Lioplacodes nebrascensis (Meek and Hayden)
Lioplacodes limnaeiformis (Meek and Hayden).

With one exception, all of these species occur in the Ravenscrag Formation farther west. *Corbula mactriformis* is known elsewhere from the Lebo Formation of central North Dakota. Until its stratigraphic distribution in the Fort Union Group is known in more detail, its restricted range may be interpreted as environmental, perhaps associated with the proximity of the Cannonball sea.

A rich locality for fossil mammals in the Roche Percée area is currently being exploited by the Manitoba Museum of Man and Nature under the direction of G. E. Lammers (per. comm.). Because of the high position in the formation it is to be expected that the age will prove to be Tiffanian (Late Paleocene).

In any attempt to correlate the Ravenscrag Formation with the Fort Union Group of eastern Montana, the key area is in Sheridan County, along Big Muddy Valley and its tributaries. With detailed work it should be possible to trace horizons from here into the extensive exposures southwest of Big Muddy Lake, Saskatchewan. Fig. 1F is a columnar section of the Fort Union Formations present in the Scobey-Plentywood coal field, compiled from data in Collier (1924), supplemented by personal observations. In accordance with U.S. Geological Survey practice at the time, the Tullock "Member" was classified by Collier as the upper part of the Lance

Formation, although it was recognized that dinosaur bones were not present above the coal seam ("A") which marks the Hell Creek-Tullock contact. The Tullock is distinguished here by the presence of massive yellowish sandstones and shales, alternating with banded grey and brown shales with coal seams. There is supposed to be a resemblance to the Tongue River beds, which are much higher in the section, but the Tullock that I have seen here is not much different from the overlying Lebo Formation. The latter in the Plentywood area is very similar to the grey facies of the Ravenscrag Formation, i.e., grey and brown clays and impure sandstones, with numerous coal seams. These Lebo rocks do not resemble closely the highly andesitic shales of the type Lebo in the Crazy Mountain area (Stone and Calvert, 1910), which have yielded important mammalian faunas of Torrejonian (Middle Paleocene) age (Simpson, 1937). The thickness of the Lebo Formation in the Plentywood area is given by Collier (1924) as 200 to 275 ft (approx. 60 to 80 m). As compared with the Big Muddy Valley section in Saskatchewan (Fig. 1E), the Lebo is as thick as, or thicker than, the grey facies of the Ravenscrag, and if we add the Tullock, as we must if the lowest coal seams are about the same in age, then there is a marked thickening of the grey facies from the Ravenscrag to the Big Muddy section to the Tullock/Lebo of the Plentywood section.

The analogue of the buff Ravenscrag in the Plentywood area is the Tongue River Formation. This consists of buff or yellowish, fine-grained sandstones and light grey or buff clays. Coal seams are less numerous than in the Lebo Formation. Just west of the town of Plentywood, in sect. 11, twp 35N, rge 54E, there is an exposure of white-weathering beds, including about 2 ft (0.6 m) of what appears to be refractory clay. If this is a southeastern extension of the Willowbunch Member, it is of interest that it lies near the Lebo-Tongue River contact, rather than 100 feet or more above the grey-buff transition, as in adjacent Saskatchewan.

The Missouri River valley of eastern Montana and adjacent North Dakota is the classic area for the study of the Fort Union Group. The site of old Fort Union, a familiar landmark to F. V. Hayden, is almost at the base of extensive "badlands" exposures of Tongue River beds. The section in this area (Fig. 1G) is essentially the same as that of the Plentywood area, with the coal-bearing Tullock Formation overlying the dinosaur-bearing Hell Creek Formation, and overlain in turn by the Lebo, Tongue River, and Sentinel Butte formations. The Tullock Formation is well exposed in McCone County (Collier and Knechtel, 1939), where it is 165 ft (50 m) thick. It consists of grey and brown clays and impure sandstones, interbedded with thick lenses of fine-grained, light buff sandstone. There are numerous coal seams. Here again the resemblance is to the grey facies of the Ravenscrag. The contact of the Tullock with the dinosaur-bearing (Lancian) Hell Creek Formation is again marked by a coal seam, here called the Z seam. At a locality known as Purgatory Hill, 26 miles (42 m) south of Fort Peck, there is a shell bed 116 ft (35 m) above the Z seam that has yielded a Puercan mammalian fauna (Sloan and Van Valen, 1965). It may be more than a coincidence that the Purgatory Hill fauna occurs at about the same height above the Z seam as does the Pine Cree Park faunule of the Ravenscrag above the No. 1 seam.

The overlying Lebo Formation, about 400 ft (120 m) thick, consists mainly of dark grey and brown clay, with some light-coloured sandstone. Except for the "U" seam at the base there is very little coal in the Lebo here. The dark colour of the clay may be due to the presence of volcanic material, a characteristic constituent of the type Lebo farther west (Stone and Calvert, 1910). The Lebo passes by a rather vague contact into the overlying Tongue River Formation, the most widespread of the Fort Union formations of northeastern Montana. The Tongue River rocks are predominantly buff and light grey clayey sandstones and sandy or bentonitic clays. The general light colour of the beds is accentuated by the leaching out of salts that give a thin white veneer to the exposed surfaces. The resemblance to the buff facies of the Ravenscrag Formation is marked. Collier and Knechtel (1939) estimated the thickness of the Tongue River Formation in McCone County as about 700 ft (approx. 200 m). Farther east the formation is extensively exposed in the Missouri and Yellowstone River valleys in Roosevelt and Richland counties.

In spite of the resemblance of the Tongue River beds to the buff Ravenscrag of Saskatchewan, it is evident (Fig. 1) that the former is mostly, if not entirely, higher in the section. The non-marine molluscs of the Tongue River Formation, well described and figured by Meek (1876), include nearly all of the species that occur in the Ravenscrag, and this fauna continues into the overlying Sentinel Butte Formation. A single occurrence of a fossil mammal has been recorded from well up in the Tongue River Formation northeast of Fort Buford, North Dakota. This is a pantodont, *Titanoides primaevus* Gidley (1917), of Tiffanian age.

Conclusions

The Ravenscrag Formation of southwestern Saskatchewan is the temporal correlative of the Tullock and Lebo formations and possibly a lower portion of the Tongue River Formation. The transition from the lower or grey facies of the Ravenscrag to the upper or buff facies is not a time boundary, but rises in the section from west to east. It is analogous to the Lebo-Tongue River contact but is not the stratigraphic equivalent. The molluscan fauna of the Ravenscrag Formation consists entirely of freshwater species; they range throughout most of the formation and in Montana and North Dakota continue upward into the Tongue River and Sentinel Butte formations. The mammal jaw from the Ravenscrag of Pine Cree Park indicates that at least the lower 120 ft (36 m) of the formation here is of Puercan (Early Paleocene) age. The buff facies probably includes Torrejonian (Middle Paleocene) equivalents. The discovery of Tiffanian (Late Paleocene) mammals in the Ravenscrag of Alberta suggests that they might also be found in upper beds in the Cypress Hills of Saskatchewan. A Tiffanian age for the Ravenscrag of the Souris River valley of southwestern Saskatchewan is highly probable.

The Paskapoo Formation of central Alberta contains nearly all of the molluscan species present in the Ravenscrag Formation but with important additions of terrestrial gastropods, reflecting a somewhat different environment. Nearly all of the Paskapoo mammals are of Tiffanian age (Russell, 1958). In the Red Deer River valley the beds formerly assigned to the top of the Edmonton Formation and lying above the Ardley coal seam may be of pre-Tiffanian Paleocene age and equivalent to some lower part of the Ravenscrag Formation of southwestern Saskatchewan.

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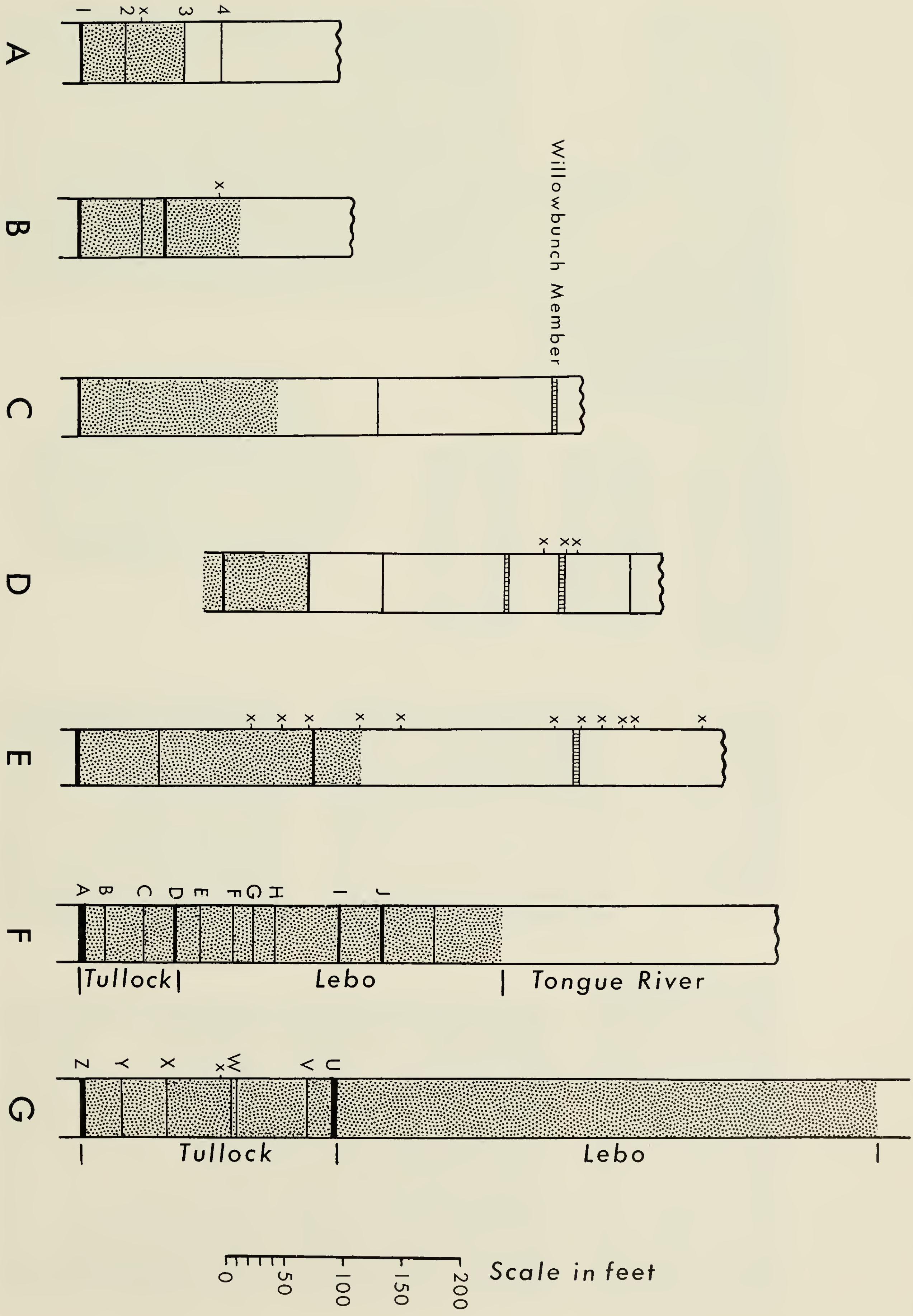
Fig. 1 Columnar sections of the Ravenscrag Formation of Saskatchewan and equivalent Fort Union formations of eastern Montana. Stippled pattern represents strata predominantly grey and brown clays and clayey sandstones; clear portions represent strata predominantly buff-coloured sandstone and siltstone; solid lines with numbers or letters represent coal seams; vertical cross-hatching represents kaolinized clay; small X indicates fossil occurrences. A to E based on McLearn (Fraser *et al.*, 1935); F modified after Collier (1924); G based on Collier and Knechtel (1939).

A. Ravenscrag Butte, west of Eastend, Saskatchewan.
B. Anxiety Butte, east of Eastend.
C. Gwendella Valley, south of Fir Mountain.
D. Willow Bunch area.
E. Big Muddy Valley (composite).
F. Scobey-Plentywood area, Montana.
G. McCone and Richland Counties, Montana.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Lebo
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50
100
150
200
Scale in feet

Fig. 2 Ravenscrag fossils, magnification as indicated.

A. *Plesielliptio priscus* (Meek and Hayden), ROM (IP) 29284, left valve, external view, × 2.

B. *Fusconia tuchiasana* (Russell), paratype, GSC 6786, Big Muddy 11, right valve, external view, × 1; GSC negative 202026.

C. *Sphaerium formosum* (Meek and Hayden), GSC 74762, Calf Creek, both valves, external view, × 4.

D. *Sphaerium fowleri* Russell, GSC 21523, Calf Creek, left valve, external view, × 4.

E. *Corbula mactriformis* Meek and Hayden, ROM(IP) 29884, Roche Percée, right valve, external view, × 2.

F. Same, internal view, × 2.

G. *Hydrobia anthonyi* (Meek and Hayden), GSC, Big Muddy 6, dorsal view, × 4.

H. Same, apertural view, × 4.

I. *Hydrobia warrenana* (Meek and Hayden), ROM(IP) 29885, Pine Cree Park, dorsal view, × 4.

J. Same, apertural view, × 4.

K. *Viviparus leai* (Meek and Hayden), GSC, Big Muddy 23, dorsal view, × 2.

L. Same, apertural view, × 2.

M. *Lioplacodes nebrascensis* (Meek and Hayden), ROM(IP) 29288, Pine Cree Park, apertural view, × 2.

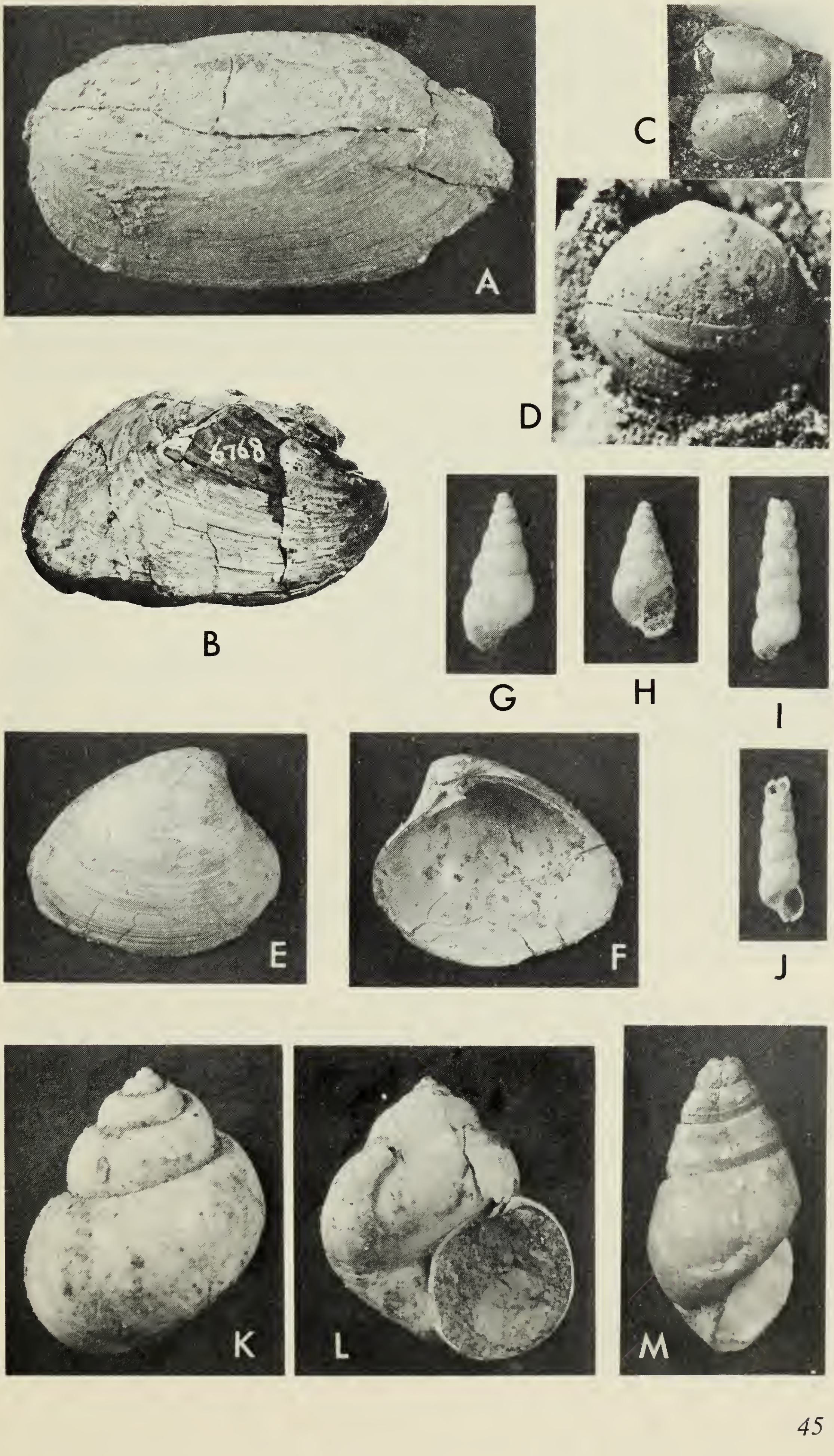
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Fig. 3 Ravenscrag fossils, magnification as indicated.

A. *Viviparus trochiformis* (Meek and Hayden), GSC, Big Muddy 23, dorsal view, × 2.

B. Same, apertural view.

C. *Viviparus leidyi* (Meek and Hayden), GSC, Big Muddy 23, dorsal view, × 2.

D. Same, apertural view, × 2.

E. *Viviparus formosus* Meek, GSC, Big Muddy 17, dorsal view, × 2.

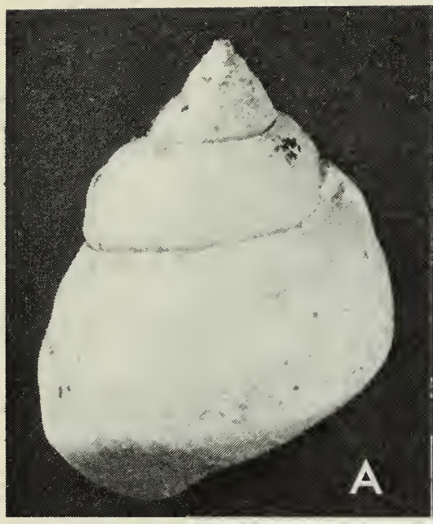
F. Same, apertural view, × 2.

G. *Lioplacodes limnaeiformis* (Meek and Hayden), ROM(IP) 29895, Roche Percée, dorsal view, × 2.

H. Same, apertural view, × 2.

I. *Lioplacodes nebrascensis* (Meek and Hayden), ROM(IP) 29288, immature specimen, Pine Cree Park, dorsal view, × 4.

J. Same, apertural view, × 4.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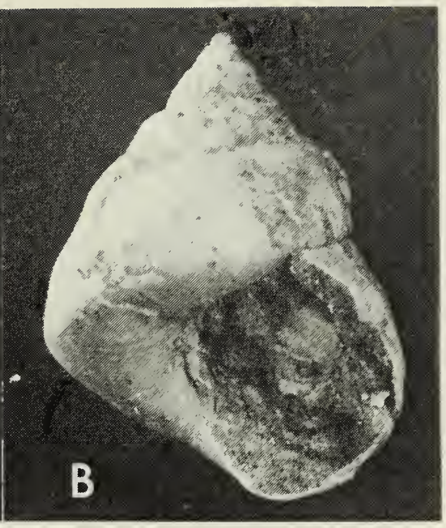
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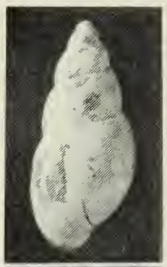
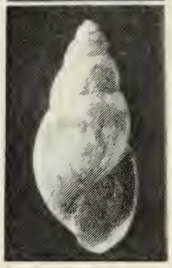
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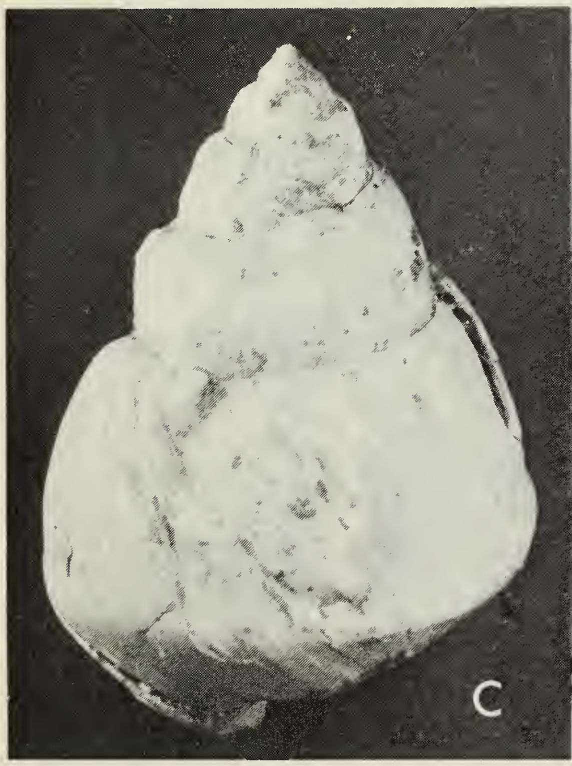
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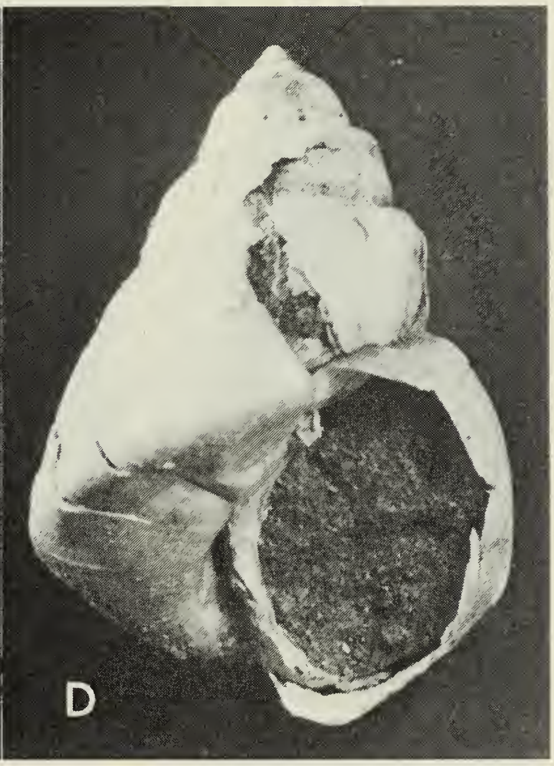
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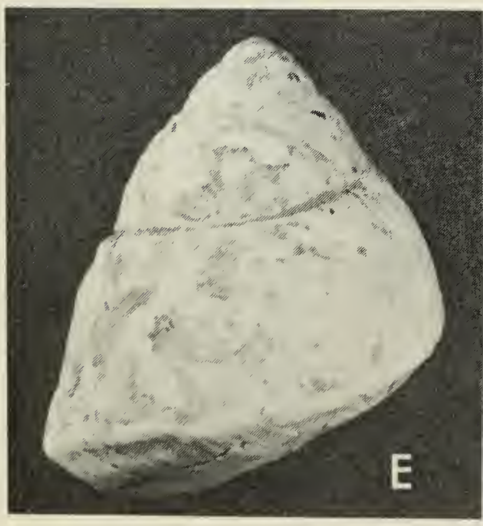
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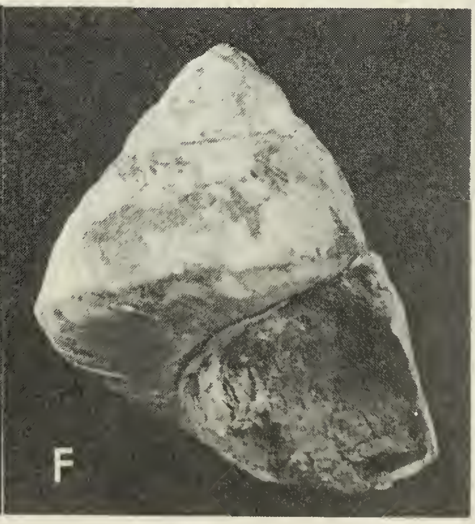
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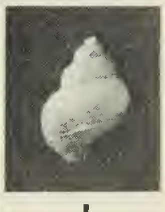
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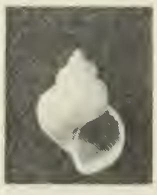
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Fig. 4 Ravenscrag fossils, magnification as indicated.

A. *Campeloma nebrascense whitei* Russell, GSC, Chimney Coulee, dorsal view, × 2.

B. Same, apertural view, × 2.

C. *Lioplacodes nebrascensis* (Meek and Hayden), ROM(IP) 29289, Souris River, dorsal view, × 2.

D. Same, apertural view, × 2.

E. ? *Lioplacodes nebrascensis* (Meek and Hayden), ROM(IP), operculum, external view, × 4.

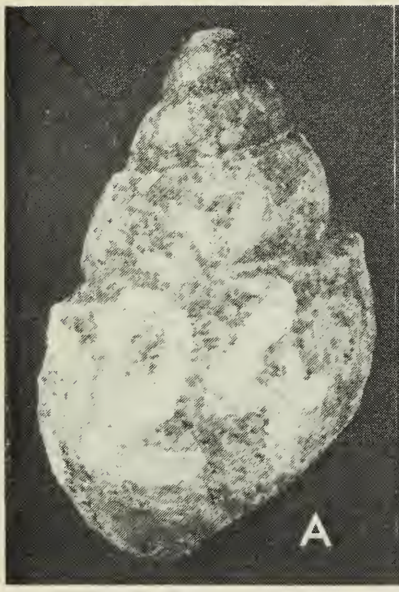
F. Same, another specimen, internal view, × 4.

G. *Lioplacodes tenuicarinata* (Meek and Hayden), GSC, Knollys, dorsal view, × 4.

H. Same, apertural view, × 4.

I. *Physa canadensis* Whiteaves, GSC, Big Muddy 23, dorsal view, × 2.

J. Same, apertural view, × 2.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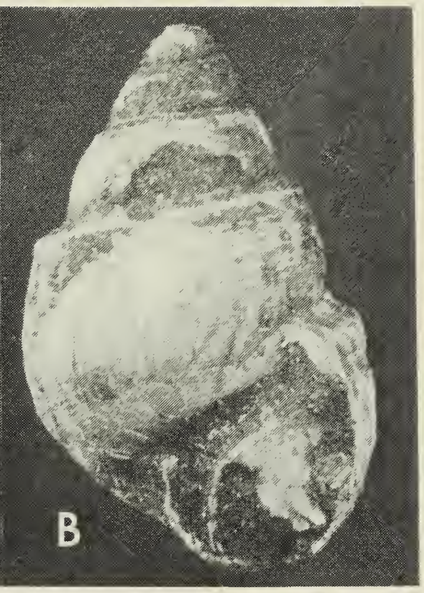
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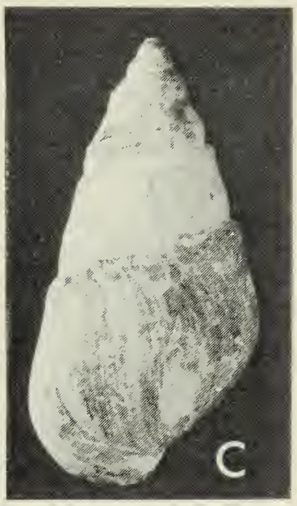
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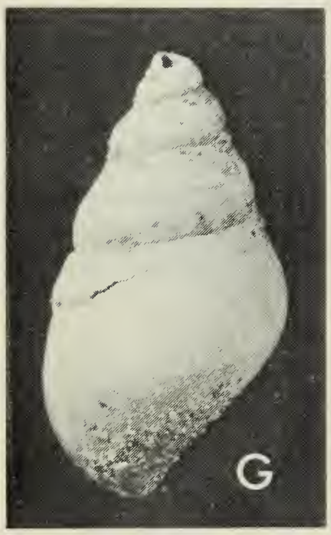
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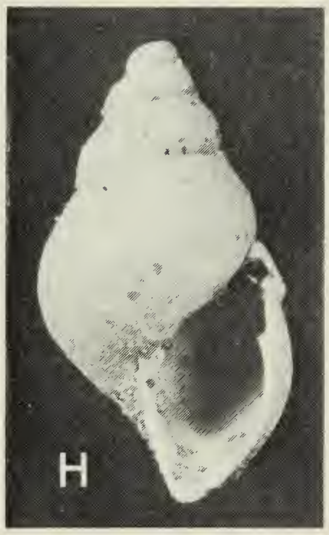
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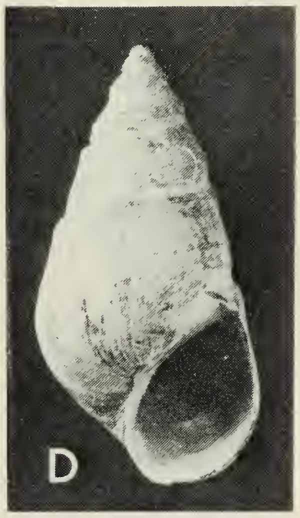
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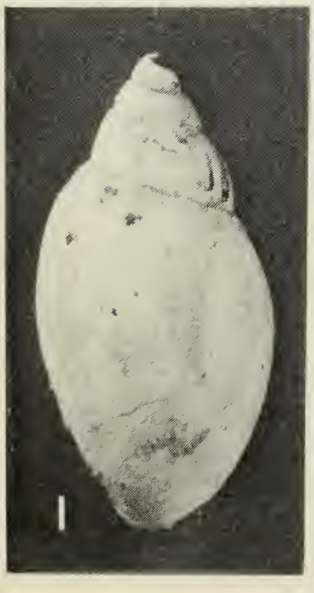
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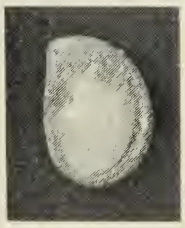
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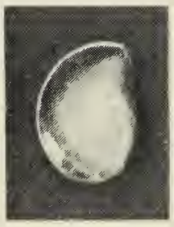
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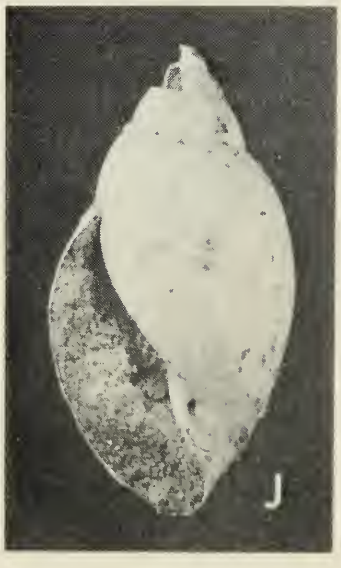
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Fig. 5 Ravenscrag fossils, all × 2.

A. *Physa canadensis ampla* Russell, GSC, Big Muddy 23, dorsal view.

B. Same, apertural view.

C. *Lepisisteus* sp., ROM(VP), anterior median scale, Pine Cree Park, external view.

D. *Lepisosteus* sp., ROM(VP), posterior median scale, Pine Cree Park, external view.

E. *Lepisosteus* sp., ROM(VP), cranial bone fragment, Pine Cree Park, external view.

F. *Lepisosteus* sp., ROM(VP), cranial bone fragment, Pine Cree Park, external view.

G. *Lepisosteus* sp., ROM(VP), anterior vertebral centrum, Pine Cree Park, dorsal view.

H. *Lepisosteus* sp., ROM(VP), posterior vertebral centrum, Pine Cree Park, dorsal view.

I. *Lepisosteus* sp., ROM (VP), anterior flank scale, Pine Cree Park, external view.

J. *Lepisosteus* sp., ROM(VP), flank scale, Pine Cree Park, external view.

K. *Lepisosteus* sp., ROM(VP), flank scale, Pine Cree Park, external view.

L. *Lepisosteus* sp., ROM(VP), posterior flank scale, Pine Cree Park, external view.

M. Unidentified holostean, ROM(VP), flank scale, Pine Cree Park, external view.

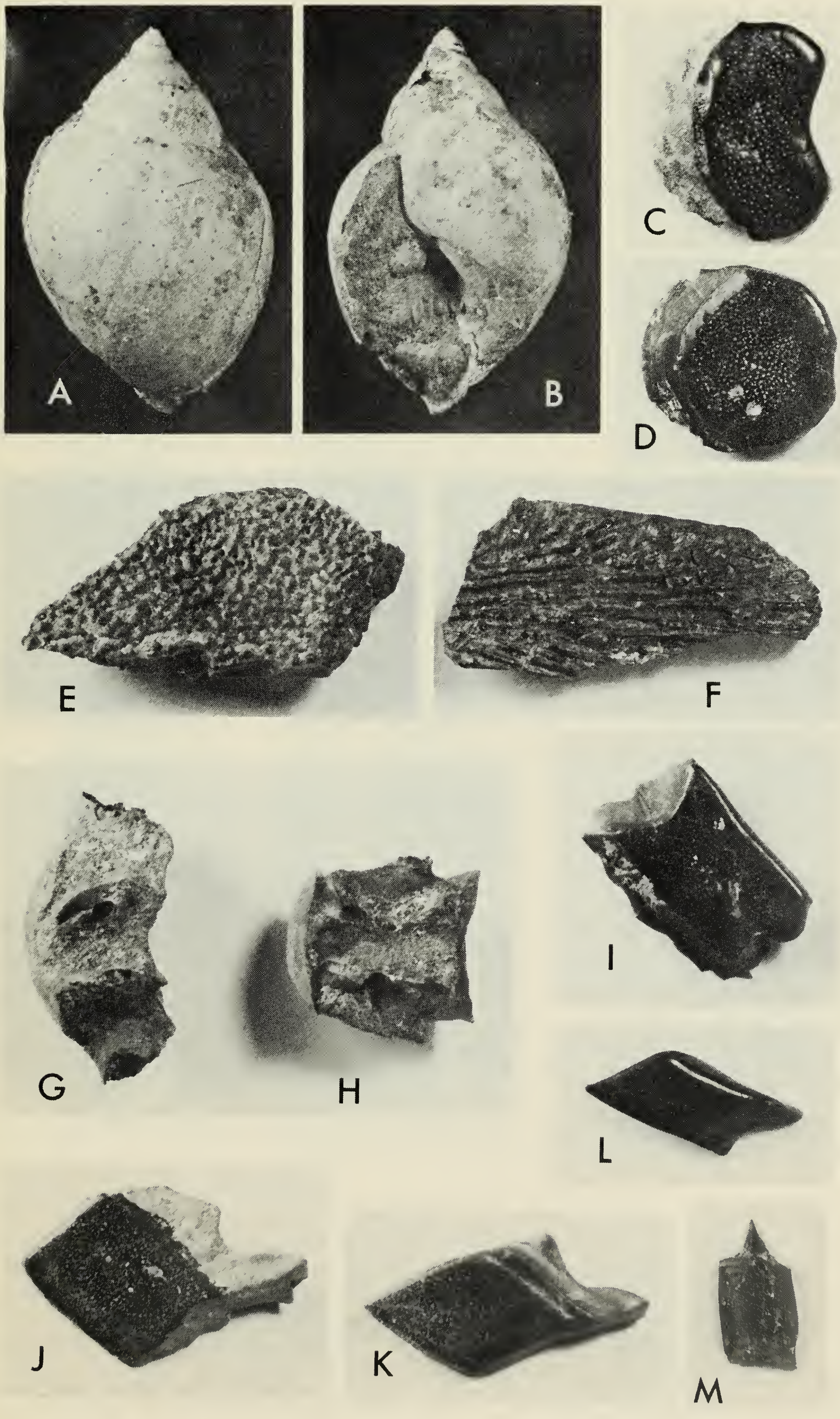
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Fig. 6 Ravenscrag fossils, magnification as indicated.

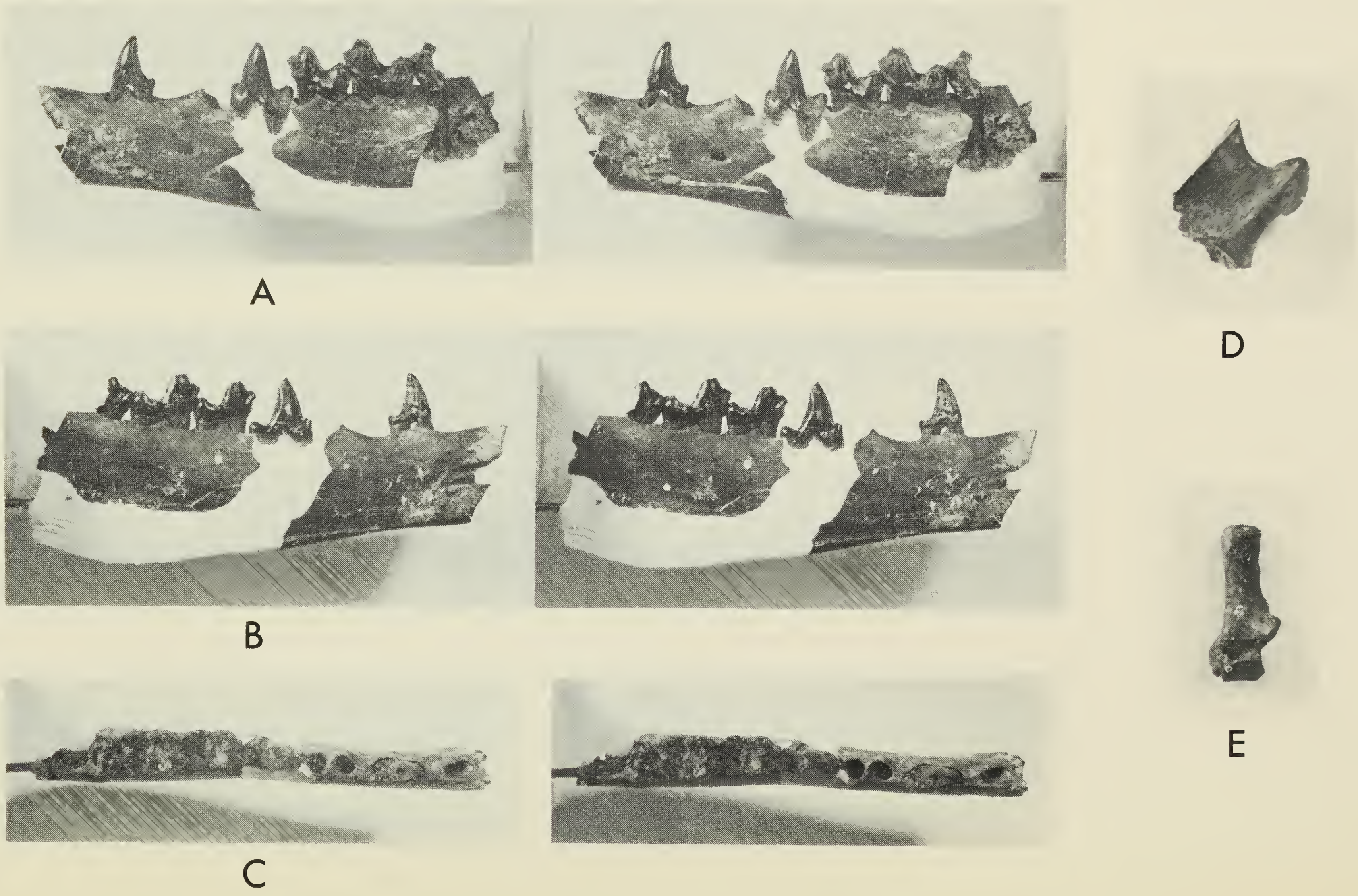
A. *Carcinodon aquilonius,* n. sp., ROM(VP) 12865, type, fragmentary left mandibular ramus, Pine Cree Park, stereoscopic pair, external view, × 2.

B. Same, internal view, × 2.

C. Same, occlusal view, × 2.

D. Same, condylar region, external view, × 2.

E. Unidentified calcaneum, ROM(VP) 12866, Pine Cree Park, dorsal view, × 4.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